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NEW YORK-NEW JERSEY AIR POLLUTION ABATEMENT ACTIVITY:PARTICULATE MATTER. PHASE II. PRE-CONFERENCE INVESTIGATIONS

National Center for Air Pollution Control
Cincinnati, Ohio

December 1967

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NEW YORK - NEW JERSEY
AIR POLLUTION ABATEMENT ACTIVITY
PARTICULATE MATTER
PHASE II. PRE-CONFERENCE INVESTIGATIONS

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U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
Public Health Service
Bureau of Disease Prevention and Environmental Control
National Center for Air Pollution Control

Cincinnati, Ohio
December 1967

- ERRATA -

1. Page 48 - Table 22: "$D > 5\ \mu$" should read "$D < 5\ \mu$."

2. Page 83 - Paragraph 2, line 4: "Another area of high values is found in the Rockaway area around Queens (No. 163)" should read "Isolated areas of high dustfall concentrations are found in Staten Island (Station 169) and in the Southeastern corner of Queens (Station 163)."

3. Page 128 - Table B1: The 24 dustfall stations listed on the following two pages should be added to this table.

Station number	Agency	Address	Sampler			
			Hi-Vol	AISI	Dustfall	Respirable
150	NYC	5-7 Rutgers Place Manhattan, N.Y.			X	
151	NYC	445 East 69th St. Manhattan, N.Y.			X	
153	NYC	9th Ave. & West 13th St. Manhattan, N.Y.			X	
154	NYC	304 West 31st St. Manhattan, N.Y.			X	
156	NYC	295 Flatbush Ave. Brooklyn, N.Y.			X	
157	NYC	Noll St. & Central Ave. Brooklyn, N.Y.			X	
158	NYC	Ridge Blvd. & 86th St. Brooklyn, N.Y.			X	
159	NYC	21st St. & 31st Dr. Queens, N.Y.			X	
160	NYC	98th St. & 25th Ave. Queens, N.Y.			X	
161	NYC	90th St. & 55th Ave. Queens, N.Y.			X	
162	NYC	222nd St. & 92nd Rd. Queens, N.Y.			X	
163	NYC	Beach 25th St. & Cornaga Ave. Queens, N.Y.			X	
166	NYC	Radcliffe St. & Adee Ave. Bronx, N.Y.			X	
167	NYC	St. George Ave. & Slossen Terrace Staten Island, N.Y.			X	
168	NYC	201 Arlington Ave. Staten Island, N.Y.			X	
169	NYC	4108 Victory Blvd. Staten Island, N.Y.			X	

Station number	Agency	Address	Sampler			
			Hi-Vol	AISI	Dustfall	Respirable
001E	USPHS	U.S. Weather Bureau Auxillary Instrumentation Site May's Landing, N.J.			X	
002E	USPHS	Perth Amboy Housing Authority 881 Amboy Ave. Perth Amboy, N.J.			X	
003E	USPHS	Elizabeth Police Station East Jersey St. & Morrell St. Elizabeth, N.J.			X	
004E	USPHS	Willowbrook State School 2760 Victory Blvd. Staten Island, N.Y.			X	
005E	USPHS	Guard Station Brooklyn Navy Yard Brooklyn, N.Y.			X	
019E	USPHS	Nassau County Voter Registration Bldg. Old Country Road Mineola, N.Y.			X	
020E	USPHS	Archbishop Stepinac H.S. Mamaroneck Ave. White Plains, N.Y.			X	
021E	USPHS	East Port Chester Fire House Greenwich, Conn.			X	

This report is based upon an investigation of particulate matter air pollution conducted in the New York - New Jersey metropolitan area in 1966 and 1967. The report is intended to assist the governmental agencies concerned with such air pollution in their consideration of the following:

1. Occurrence of air pollution subject to abatement.
2. Adequacy of measures taken toward abatement of pollution.
3. Nature of delay, if any, in abating the pollution.
4. Necessary remedial action, if any.

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NEW YORK - NEW JERSEY
AIR POLLUTION ABATEMENT ACTIVITY
PARTICULATE MATTER
PHASE II. PRE-CONFERENCE INVESTIGATIONS

I. INTRODUCTION

This is the second in a series of reports prepared to describe air pollution in a 17-county metropolitan area of southeastern New York and northeastern New Jersey. The report covers Phase II of a study being conducted jointly by the Public Health Service, Department of Health, Education, and Welfare; the State Departments of Health of New York and New Jersey; the Interstate Sanitation Commission; the City of New York; and a number of other local agencies. It is concerned with air pollution by particulate matter, the degree to which this type of pollutant is prevalent in ambient air, the principal sources of such pollutants, and the meteorology by which particulate air pollution is transported within the study area. This information is presented in connection with the second session of the New York - New Jersey air pollution conference called by the Secretary of Health, Education, and Welfare on November 11, 1966. Authority for the interstate abatement action is provided by the Clean Air Act as amended (42 USC 1857, et seq.). A Phase I report entitled New York - New Jersey Air Pollution Abatement Activity, Sulfur Compounds and Carbon Monoxide, January 1967,[1] together with other pertinent information, was presented in the initial session of the abatement conference held in New York City in January 1967. Conclusions and recommendations of this session of the conference are presented in Appendix A of this report.

Particulate air pollution includes materials of widely differing chemical and physical properties. For purposes of this report, the term includes all substances except uncombined water that are solids or liquids under ordinary conditions. Thus, finely divided oil droplets and sulfuric and phosphoric acid mists are considered particulates along with more obvious solid contaminants such as rock dust, metallurgical fumes, and fly ash from refuse incineration and coal burning. Some particulate air contaminants, because of size or chemical make-up, are more toxic, more corrosive, and more a threat to health and welfare than are others.

Principal sources of particulate matter generated by the activities of man include the combustion of heating and automotive fuels, refuse disposal, construction and demolition, and industrial processes. Pollutants from these sources add to the dust, salt mist, and other background particulates attributable to natural causes. Air sampling programs throughout the country have shown decidedly greater particulate concentrations in urban atmospheres than in those of nonurban areas. Evaluations and conclusions contained in this report reflect the scientific and technical judgement of personnel of the National Center for Air Pollution Control, Public Health Service, U. S. Department of Health, Education, and Welfare.

HISTORY OF ABATEMENT ACTION

The existence of air pollution in the New York - New Jersey interstate area has been acknowledged since the early 1900's. Various economic and social pressures have combined to add, expand, diminish, and, in a few instances, eliminate pollution sources. Although these forces have reduced or eliminated such practices as uncontrolled coal burning, copper ore smelting, and hog farming in the area, the resultant gains have been more than offset by increases in power generation, fuel burning, industrial operations, and use of motor vehicles. The overwhelming trend has been toward greater pollution in the interstate airshed.

Initial studies and investigations tended to show the adverse effects that air pollution arising in New Jersey has on residents of Staten Island and Manhattan. As noted in the initial Phase of the interstate conference, other studies over the past 11 years have shown the pollution to travel from either state to the other and to endanger the health and welfare of citizens of both states.

For purposes of this report, it will suffice to cite the following pertinent dates and facts in the history of the abatement action.

December 17, 1963	President Johnson signed the Clean Air Act (Public Law No. 88-206), which authorizes the Department of Health, Education, and Welfare to engage directly in interstate air pollution abatement activities.
July 8, 1964	Congressman John M. Murphy wrote the Secretary of Health, Education, and Welfare, Anthony Celebrezze, stating that air pollution from New Jersey was endangering the health and welfare of residents of portions of New York City, and requesting that appropriate action be taken under the provisions of the Clean Air Act.
Summer 1965	An air sampling program was conducted in Staten Island and adjacent portions of New Jersey.
October 15, 1965	Governor Nelson A. Rockefeller of New York requested that the Secretary of Health, Education, and Welfare call a conference under the Clean Air Act regarding air pollution discharged in New Jersey alleged to endanger health and welfare of persons in the State of New York.
November 5, 1965	Secretary of Health, Education, and Welfare John W. Gardner indicated that he would call a consultation under the Clean Air Act. He pointed out that consideration should also be given to air pollution originating in New York that might endanger health and welfare of persons in New Jersey. Governor Richard J. Hughes of New Jersey was advised of this action.
April-December 1966	An investigation of sulfur compounds and carbon monoxide in the 17-county area was undertaken by the Public Health Service, the States

	of New York and New Jersey, and local agencies.
January 1967	The initial phase of an interstate air pollution abatement conference was held in New York City regarding air pollution from sulfur compounds and carbon monoxide. Recommendations for the abatement of these air contaminants were developed by the conference participants.
March 1967	Secretary of Health, Education, and Welfare John W. Gardner issued recommendations for abatement of sulfur compounds and carbon monoxide in the metropolitan area that were essentially the same as those agreed to by the conference participants.
March 1967	The second phase of the interstate abatement activity, a study of particulate matter air pollution, was initiated.

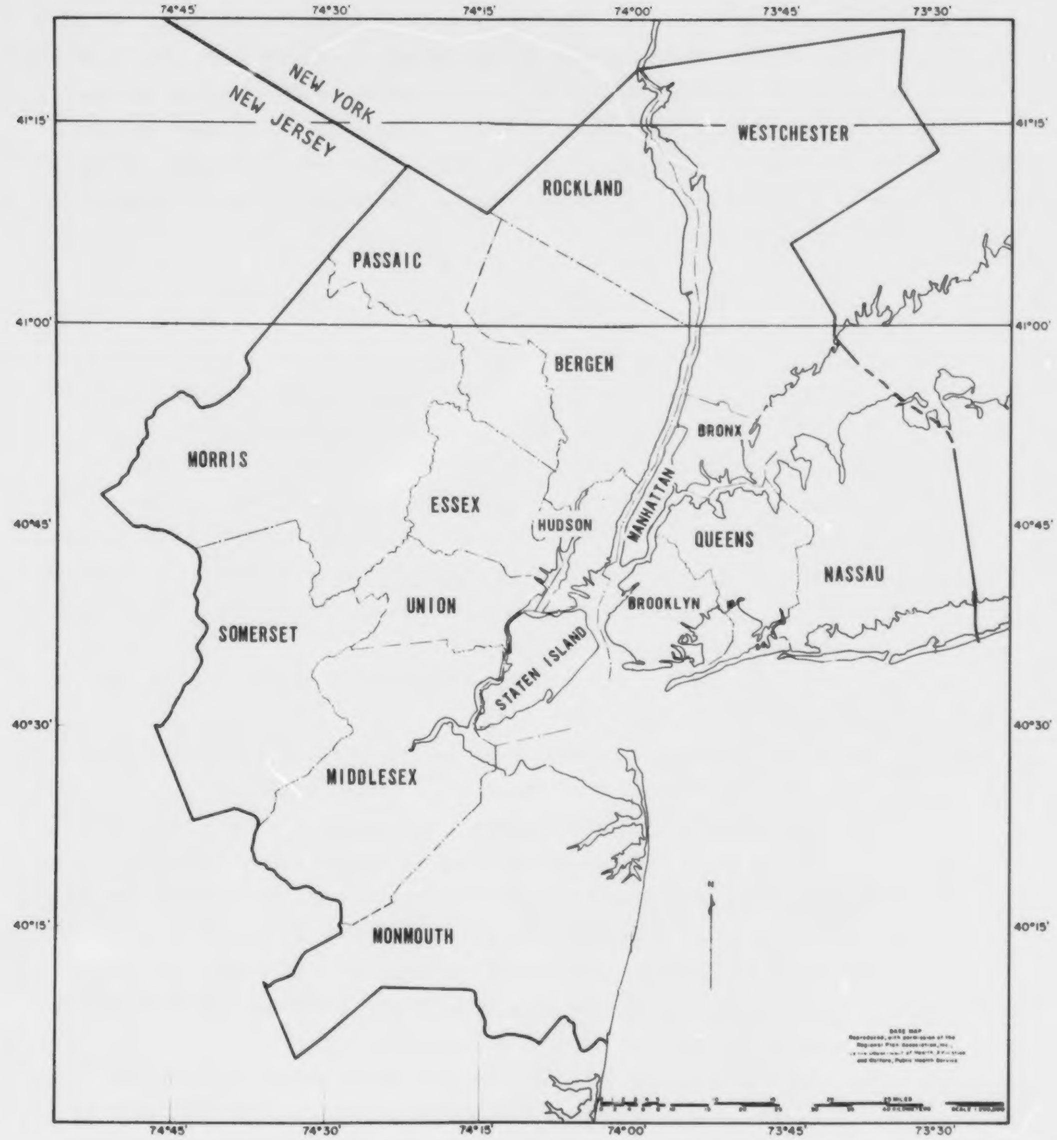
DESCRIPTION OF STUDY AREA

The interstate study area (Figure 1) includes Bergen, Essex, Hudson, Middlesex, Monmouth, Morris, Passaic, Somerset, and Union counties in northeastern New Jersey; the five boroughs of New York City; and Nassau, Rockland, and Westchester counties in New York. Most of the area lies within 35 miles of Bayonne, New Jersey.

The topography and distribution of population, industry, and commerce are described in the Phase I report. Except for slight population shifts, there were no major changes in these conditions from 1965 to 1966. The over-15-million population and the number of air pollution sources are expected to continue to increase, particularly in the outlying counties.

CLIMATOLOGY

In the Phase I report, the six weather parameters that affect air pollution are discussed in some depth. These include: wind speed and direction, turbulence, precipitation, temperature, and stagnation of anticyclones. The information shows that climatology of the study area provides better ventilation than exists in most metropolitan areas of the country. In addition, low-level winds from the north and west frequently blow pollutants to sea.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ESSEX
HUDSON
MANHATTAN
QUEENS
NASSAU
UNION
BROOKLYN
SOMERSET
STATEN ISLAND
MIDDLESEX
MONMOUTH
N

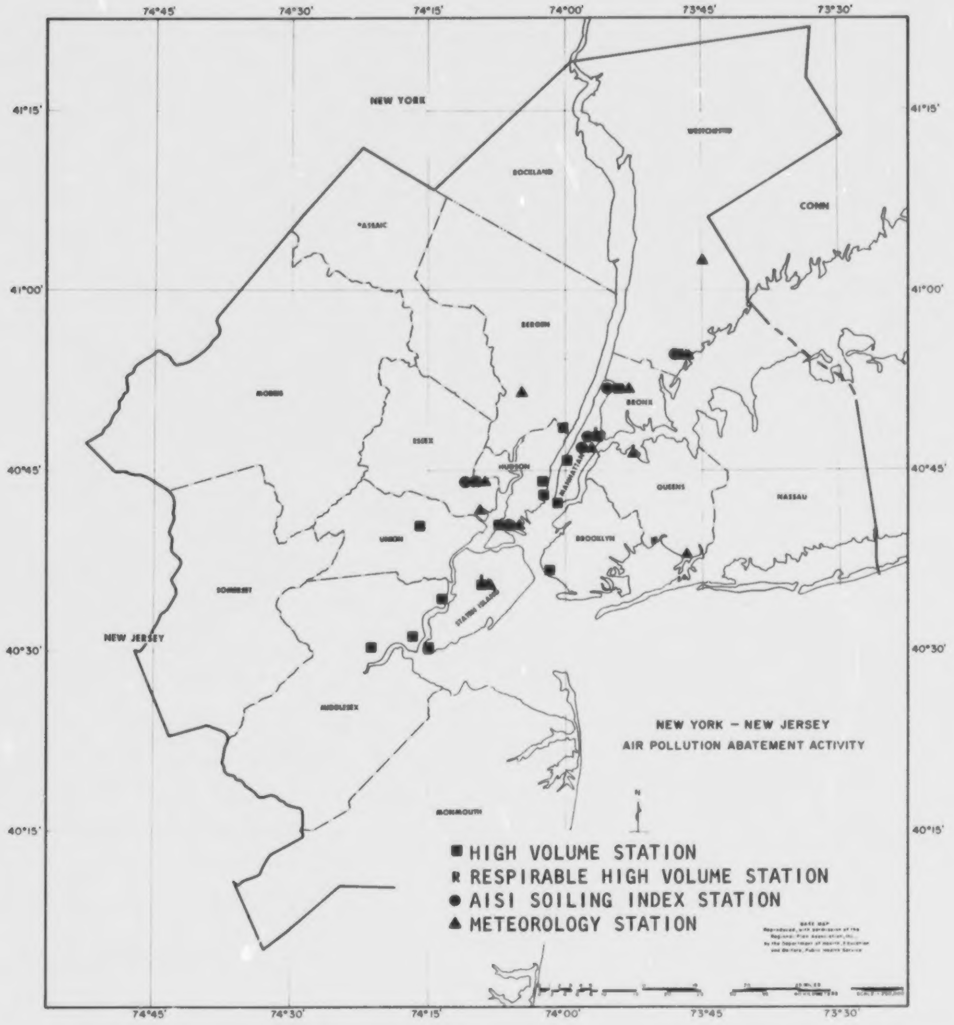
Figure 1. New York - New Jersey air pollution abatement activity area.

The favorable natural ventilation is not particularly reassuring in light of existing air contaminant levels and New York City's recent ranking as the most polluted of U. S. cities.[2] Even though ventilation generally is good, the area is subject on occasion to periods of several days duration during which extremely poor diffusion conditions persist. Serious levels of contaminants occur and will continue to occur during these periods unless emissions are reduced. Based on past records, the New York Metropolitan Area will average two such episodes per year. In one-half of the years an episode will occur in September or October and one-third of the episodes will persist 6 days or more. The longer episodes are most likely to occur in the fall. The longest stagnation period on record lasted 10 days; it occurred in November 1962.

PROJECT DESIGN

Because the characteristics of particulate air contaminants are somewhat different from those of gaseous pollutants, the project design was not identical to that of Phase I. Consistent with overall abatement objectives, it was agreed that the network would maintain continuity of sampling sites wherever possible. Orientation of sites with respect to wind directions and emissions sources would be consistent with Phase I operations. Figures 2 and 3 show locations of suspended particulate, dustfall, and meterological stations within the study area. Station locations are given in Appendix B. Pursuant to the objectives and scope of the abatement activity the participants decided that:

1. The Phase I air quality monitoring network should be refined and expanded to:
    a. Place particulate sampling equipment in operation at locations supplementing those of the Phase I investigation.
    b. Employ techniques and equipment that would describe the chemical and physical make-up of particulate matter air contaminants.
2. An emissions inventory of particulate matter emissions from industrial, commercial, governmental, and residential sources would be conducted to:
    a. Provide positive evidence of the existence of source emissions within the study area and define their locations, magnitudes, and relative contributions of pollutants.
    b. Provide data for calculations that would demonstrate whether interstate transportation of pollutants occurs and the magnitude of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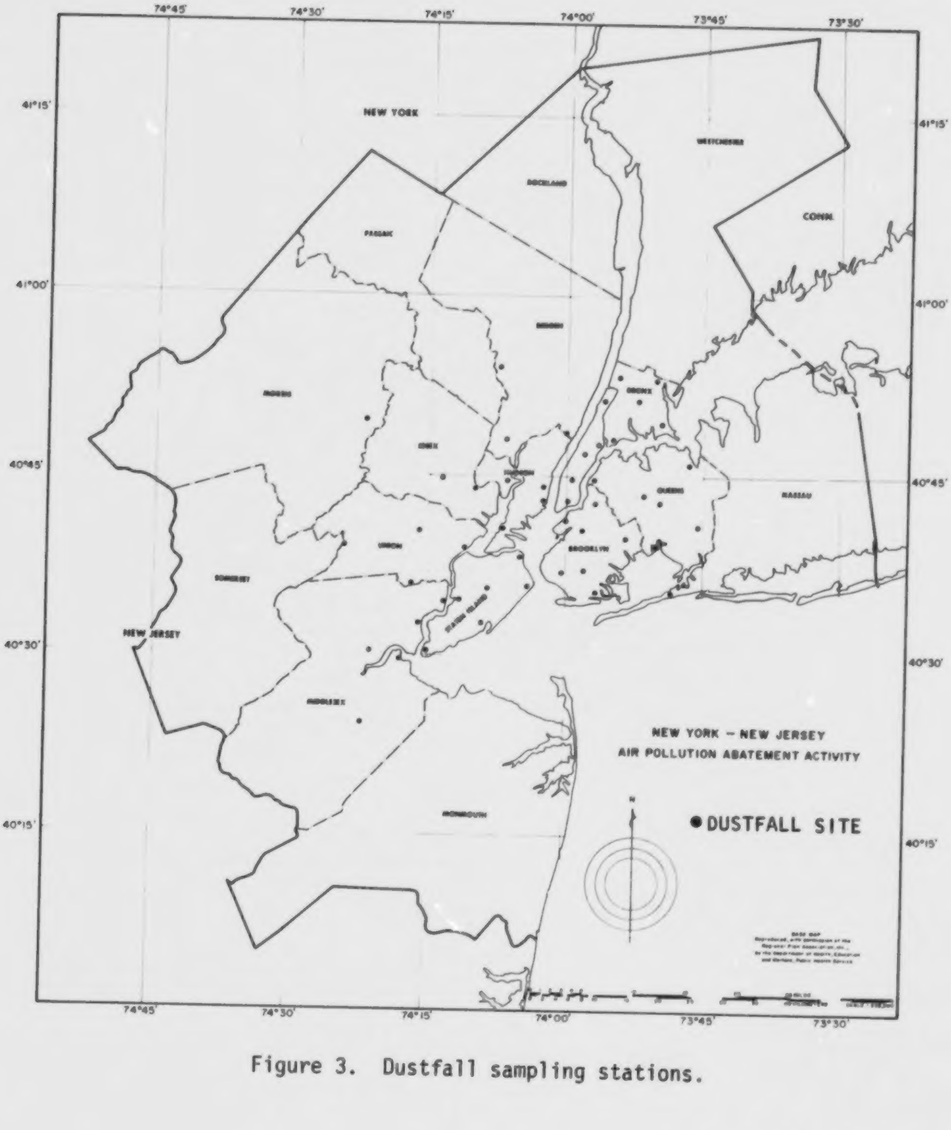
MANHATTAN
QUEENS
NASSAU
UNION
BROOKLYN
SOMERSET
STATEN ISLAND
NEW JERSEY
MIDDLESEX
MONMOUTH
N
NEW YORK - NEW JERSEY
AIR POLLUTION ABATEMENT ACTIVITY
■ HIGH VOLUME STATION
R RESPIRABLE HIGH VOLUME STATION
● AISI SOILING INDEX STATION
▲ METEOROLOGY STATION

Figure 2. Sampling station locations.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HUDSON
BRONX
QUEENS
NASSAU
UNION
BROOKLYN
SOMERSET
STATEN ISLAND
NEW JERSEY
MIDDLESEX
MONMOUTH
NEW YORK – NEW JERSEY
AIR POLLUTION ABATEMENT ACTIVITY
● DUSTFALL SITE
N

Figure 3. Dustfall sampling stations.

impact of any such emissions at selected receptor sites.

c. Provide information on present distributional patterns of fuel use, refuse disposal, and industrial process emissions.

3. Rapid survey techniques similar to those of the Phase I investigation were to be employed to provide a zone-oriented data presentation. Zone boundaries were not to be altered except possibly in New York City if so indicated by the availability of data. A more detailed description of the procedure is included in Appendix C.

4. The meterological data collection system of Phase I was maintained with minor changes in equipment site locations as noted in Figure 2. Details of the system are described in Appendix A of the Phase I report. The "representativeness" evaluation would compare meterological conditions during the 1966-1967 sampling period with those of past years.

5. Data processing and analyses would again be coordinated through the Public Health Service. The system and techniques utilized are described in Appendix A of the Phase I report.

II. RESULTS OF COMPREHENSIVE SURVEY

AIR QUALITY DATA

Suspended Particulate - High-Volume Sampler

Suspended particulate concentrations as sampled by the high-volume sampler were measured at 18 locations. Each sample was of 24 hours duration with a starting time at midnight. Samples were collected 2 out of every 3 consecutive days. Almost half of the stations were in operation from July 1966 through October 1967; the other stations operated from February 1967 through October 1967. Data was also obtained from 13 sites in Westchester and Nassau counties in New York. These data are listed in Appendix D, Tables D-18 and D-19. No detailed analyses were made for these data, however the results were used in discussion of the impact of particulate pollution on the study area.

Frequency distributions of the daily measurements were computed for all values obtained during the study period for all stations. A summary of these data appears in Table 1. Ancora (Station No. 021) located outside of the study area on the New Jersey coast was situated in an area of relatively low pollution and is considered as a background station. Data obtained from it should show essentially natural pollution not associated with urban activities.

More than 50 percent of the time, all of the 17 urban stations show concentrations equal to or greater than 70 micrograms per cubic meter. The highest concentration values were found at Newark (No.007) where 65 percent of the values were greater than 120 $\mu g/m^3$, and on 121st St. in Manhattan (No.014), where values above 120 $\mu g/m^3$ were found 56 percent of the time. Results for all stations are given in Table 2.

Seasonal variations for all stations are shown in Table 3. In general little seasonal variation was noted, however, arithmetic means for the Newark (No. 007) and 121st Street (No. 014) sites were higher for October - March than for the rest of the year.

Frequency distribution figures for each station covering the entire sampling period may be found in Appendix D.

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Table 1. CUMULATIVE PERCENT FREQUENCY OF OCCURRENCE OF DAILY AVERAGES, SUSPENDED PARTICULATE BY HIGH-VOLUME SAMPLER

				Concentration, $\mu g/m^3$												
Station number	Station location	Operating period	No. obs	Min. value	Percent of time concentration is exceeded:							Max. value	Arith mean	Std dev	Geom mean	Geom std dev
					90	70	50	30	16	10	1					
001	Willowbrook	7/66-10/67	284	19	40	60	78	101	130	150	259	302	87	44	78	1.7
002	Roselle	7/66-10/67	281	24	48	72	92	113	137	151	229	255	96	41	92	1.5
003	Fairview	8/66-10/67	208	26	53	78	100	130	161	185	275	288	108	64	100	1.6
004	Ft. Hamilton	7/66-10/67	258	24	42	59	75	96	120	136	220	262	83	38	75	1.6
005	Raritan	7/66-10/67	238	19	38	55	70	91	115	131	220	243	78	35	70	1.6
006	Bayonne	7/66-10/67	195	22	48	69	88	114	141	161	267	294	98	49	88	1.6
007	Newark	7/66-10/67	197	50	83	112	141	175	213	240	370	499	152	67	141	1.5
012	N.Y.University	2/66-10/67	148	31	56	80	101	130	160	183	296	315	111	48	101	1.6
014	121st Street	7/66-10/67	145	51	70	98	123	155	190	215	340	409	145	54	123	1.5
016	New Rochelle	7/66-10/67	299	23	42	60	77	100	125	142	240	267	87	44	77	1.6
021	Ancora	2/67-10/67	115	12	30	33	40	50	60	66	100	128	44	18	40	1.5
024	L.Manhattan	2/67-10/67	77	38	50	73	92	111	130	141	181	177	94	35	92	1.4
025	M.Manhattan	2/67-10/67	100	39	67	95	116	140	169	188	275	278	124	50	116	1.5
095	Union City	2/67-10/67	107	39	57	86	110	138	161	178	229	248	115	45	110	1.5
101	Jersey City	2/67-10/67	128	46	69	92	111	138	165	182	245	247	120	45	111	1.5
108	Carteret	2/67-10/67	172	29	50	80	106	136	164	181	255	271	110	49	106	1.5
130	Tottenville	4/67- 8/67	84	17	43	61	76	97	116	129	170	178	81	32	76	1.5
132	Perth Amboy	2/67- 8/67	112	31	45	70	90	112	133	148	190	199	93	38	90	1.5

Table 2. PERCENT OF TIME CONCENTRATIONS EXCEEDED SPECIFIC VALUES - SUSPENDED PARTICULATE BY HIGH-VOLUME SAMPLER

Station number	Station location	Percent of time exceeding:			
		65 ug/m^3	80 ug/m^3	100 ug/m^3	120 ug/m^3
001	Willowbrook	66	48	32	19
002	Roselle	75	62	42	23
003	Fairview	79	67	53	40
004	Ft. Hamilton	65	46	30	15
005	Raritan	56	41	25	12
006	Bayonne	72	58	40	28
007	Newark	97	93	77	65
012	New York University	80	70	53	38
014	121st Street	99	83	68	56
016	New Rochelle	63	46	30	19
021	Ancora	10	3	2	1
024	Lower Manhattan	75	60	39	22
025	Mid-Manhattan	89	78	65	51
095	Union City	83	74	61	45
101	Jersey City	94	80	59	42
108	Carteret	76	62	53	37
130	Tottenville	61	44	27	10
132	Perth Amboy	78	58	39	22

Table 3. SUSPENDED PARTICULATE SEASONAL ARITHMETIC AND GEOMETRIC MEANS - BY HIGH-VOLUME SAMPLER (micrograms per cubic meter)

Station number	Station location	Arithmetic mean					Geometric mean				
		July-Sept. 1966	Oct.-Dec. 1966	Jan.-Mar. 1967	April-June 1967	July-Sept. 1967	July-Sept. 1966	Oct.-Dec. 1966	Jan.-Mar. 1967	April-June 1967	July-Sept. 1967
001	Willowbrook	120	92	85	84	80	82	77	76	76	78
002	Roselle	93	99	102	94	90	81	79	79	79	90
003	Fairview	116	133	112	130	96	101	111	96	108	94
004	Ft. Hamilton	84	90	82	84	81	79	78	74	78	82
005	Raritan	81	86	78	72	76	73	74	72	66	71
006	Bayonne	98	111	96	82	93	81	95	87	71	88
007	Newark	112	176	189	149	139	95	135	181	120	128
012	N. Y. University	-	-	111	110	110	-	-	100	91	105
014	121st Street	111	174	150	132	130	104	131	132	125	132
016	New Rochelle	80	97	104	83	79	73	84	93	76	74
021	Ancora	-	-	42	47	42	-	-	38	44	39
024	Lower Manhattan	-	-	100	94	87	-	-	84	86	82
025	Mid-Manhattan	-	-	141	124	118	-	-	136	114	115
095	Union City	-	-	110	121	109	-	-	101	101	104
101	Jersey City	-	-	112	134	112	-	-	101	102	107
108	Carteret	-	-	97	115	116	-	-	87	103	108
130	Tottenville	-	-	-	83	79	-	-	-	73	73
132	Perth Amboy	-	-	95	97	85	-	-	87	74	82

Blanks indicate data not available.

Sulfate Particulate

Suspended particulate samples collected at 16 sites in the study area were analyzed for their sulfate content. Samples from nine of the sites for a period of 9 months, July 1, 1966 to March 31, 1967 were analyzed. Samples from the other seven stations for a period of 2 months, February 1, 1967 to March 31, 1967 were analyzed.

Frequency distributions of the daily sulfate concentration values for the study period are given in Table 4. Thirteen of the 16 sites show concentration values equal to or greater than 15 $\mu g/m^3$ 50 percent of the time, and equal to or greater than 30 $\mu g/m^3$ 10 percent of the time. The arithmetic mean for all stations except **Ançora,** New Jersey, was 20 $\mu g/m^3$ during the study period. This value is approximately twice the value of 10.6 $\mu g/m^3$ found by the National Air Sampling Network[3] in 1964 - 1965 for 96 urban stations distributed throughout the United States.

Table 5 gives the percent of time that certain specified values for sulfate particulate are exceeded. Values in excess of 20 $\mu g/m^3$ were found at seven stations 30 to 40 percent of the time, at three stations 40 to 50 percent of the time, at two stations 50 to 60 percent of the time, and at three stations more than 60 percent of the time. The station showing the highest concentrations was located in midtown Manhattan (No. 025) at 57th Street and 10th Avenue, where all values exceeded 15 $\mu g/m^3$ and and over half of them exceeds 25 $\mu g/m^3$.

Seasonal variations among the three seasons for which analyses were made are shown in Table 6. Among the nine stations operating during this period there is little seasonal difference, with the exceptions of Newark (No. 007) and 121st Street (No. 014). Newark data showed a twofold increase in the winter value over that of summer, and 121st Street values for the winter are about two-thirds greater than those for summer.

Table 4. CUMULATIVE PERCENT FREQUENCY OF OCCURRENCE
SULFATE PARTICULATE (AS SO_4) BY HIGH-VOLUME SAMPLER

Station number	Station location	Operating period	No. obs	Concentration, μg/m³												Geom std dev
				Min. value	Percent of time concentration is exceeded:							Max. value	Arith mean	Std dev	Geom mean	
					90	70	50	30	16	10	1*					
001	Willowbrook	7/66-4/67	165	4	7	12	17	23	29	33	60	64	20	12	17	1.7
002	Roselle	7/66-4/67	145	4	5	10	14	20	26	30	42	44	17	8	14	1.9
003	Fairview	8/66-4/67	86	4	6	10	16	25	33	42	58	59	19	13	14	2.3
004	Ft. Hamilton	7/66-4/67	166	3	8	12	16	21	26	30	51	55	19	28	17	1.5
005	Raritan	7/66-4/67	128	4	7	11	15	20	26	31	65	66	18	10	16	1.7
006	Bayonne	7/66-4/67	113	4	9	13	19	25	33	38	72	75	22	12	19	1.7
007	Newark	7/66-4/67	94	2	7	12	17	25	34	39	95	96	20	15	17	2.1
014	121st Street	7/66-4/67	58	6	8	14	20	29	42	49	71	72	25	16	20	2.1
016	New Rochelle	7/66-4/67	152	2	7	11	14	20	26	29	46	48	18	12	15	1.9
021	Ancōra	2/67-4/67	29	5	5	6	8	12	17	21	29	29	11	7	9	1.7
024	L. Manhattan	2/67-4/67	25	10	10	18	21	25	28	29	32	32	22	6	21	1.4
025	M. Manhattan	2/67-4/67	15	16	17	21	25	30	34	37	38	38	26	8	25	1.4
095	Union City	2/67-4/67	32	8	8	13	18	22	28	30	41	41	20	9	18	1.6
101	Jersey City	2/67-4/67	35	8	12	15	23	28	34	38	49	49	25	10	23	1.5
108	Carteret	2/67-4/67	34	5	8	16	23	29	35	38	58	58	24	12	20	1.8
132	Perth Amboy	2/67-4/67	31	4	6	11	16	23	28	32	38	38	19	10	20	1.9

* Maximum value utilized for fewer than 50 observations.

TABLE 5. PERCENT OF TIME SULFATE PARTICULATE CONCENTRATIONS (AS SO_4) EXCEEDED SPECIFIC VALUES

Station number	Station location	Percent of time exceeding:			
		10 $\mu g/m^3$	15 $\mu g/m^3$	20 $\mu g/m^3$	25 $\mu g/m^3$
001	Willowbrook	80	60	40	25
002	Roselle	70	46	32	19
003	Fairview	67	50	38	29
004	Ft. Hamilton	83	54	35	19
005	Raritan	74	50	36	19
006	Bayonne	84	62	44	27
007	Newark	80	61	38	24
014	121st Street	84	62	47	34
016	New Rochelle	70	45	32	19
021	Ancora	34	21	7	3
024	Lower Manhattan	96	84	64	28
025	Mid-Manhattan	100	100	67	53
095	Union City	78	69	53	28
101	Jersey City	97	80	63	37
108	Carteret	85	76	59	47
132	Perth Amboy	78	53	44	34

TABLE 6. SULFATE PARTICULATE (AS SO_4) ARITHMETIC AND GEOMETRIC MEANS - BY HIGH-VOLUME SAMPLER

Station number	Station location	Arithmetic mean, $\mu g/m^3$			Geometric mean, $\mu g/m^3$		
		July-Sept. 1966	Oct.-Dec. 1966	Jan.- Mar. 1967	July-Sept. 1966	Oct.-Dec. 1966	Jan.-Mar. 1967
001	Willowbrook	20	20	20	17	17	18
002	Roselle	17	15	18	14	13	15
003	Fairview	20	22	18	16	16	15
004	Ft. Hamilton	18	20	18	15	16	14
005	Raritan	16	17	19	15	14	17
006	Bayonne	19	23	22	15	20	19
007	Newark	13	21	27	11	16	23
014	121st Street	20	25	32	17	21	27
016	New Rochelle	14	16	20	11	13	16
021	Ancora	-	-	11	-	-	9
024	Lower Manhattan	-	-	22	-	-	21
025	Mid-Manhattan	-	-	28	-	-	25
095	Union City	-	-	20	-	-	17
101	Jersey City	-	-	25	-	-	23
108	Carteret	-	-	24	-	-	20
132	Perth Amboy	-	-	19	-	-	16

Table 7 gives the percent sulfate of the total particulate loading. When all stations are compared, the percent sulfate is quite constant; the overall average for all stations is approximately 20 percent, or a 1-to-5 ratio.

Station locations are shown in Appendix B, and frequency distribution graphs for all data collected during the study period are given in Appendix D.

Table 7. PERCENT PARTICULATE SULFATE (AS SO_4) OF TOTAL SUSPENDED PARTICULATE[a] (HIGH-VOLUME SAMPLER)

Station number	Station location	Total particulate, µg/m^3	Sulfate particulate, µg/m^3	Sulfate particulate, percent
001	Willowbrook	95	20	21
002	Roselle	97	17	18
003	Fairview	122	19	16
004	Ft. Hamilton	78	19	24
005	Raritan	80	18	23
006	Bayonne	98	22	22
007	Newark	156	20	13
014	121st Street	144	25	17
016	New Rochelle	91	18	20
021	Ancora	45	11	24
024	Lower Manhattan	103	22	21
025	Mid-Manhattan	129	26	20
095	Union City	117	20	17
101	Jersey City	125	25	20
108	Carteret	108	24	22
132	Perth Amboy	96	19	20

[a] Determined from the arithmetic averages for the study period.

Acid Particulate

Suspended particulate samples collected at 16 sites were analyzed for their acid particulate concentration, which was calculated as sulfuric acid. Samples collected over a period of 9 months, July 1, 1966 - March 31, 1967 from nine of the stations and those collected over a period of 2 months, February 1, 1967 - March 31, 1967, from the other seven stations were analyzed.

Frequency distributions of the daily concentration values are given in Table 8. Data obtained from the stations for which analyses were obtained to represent the longer period are believed to reflect the more normal distribution. For all of these nine stations, values exceeding 7 ug/m^3 are found for at least 10 percent of the time.

Seasonal variations between the three seasons for which analyses were made are shown in Table 9. It may be noted that there is little seasonal variation with the exception of results for the 121st Street station (No. 014), which showed an almost three-fold increase from the summer to winter season.

Table 10 presents the percent acid as sulfuric acid, in the total suspended particulate. The acid particulate fraction was found to average 6 percent of the total suspended particulate and approximately 29 percent of the total suspended sulfate.

The background station at Ancora (No. 021) shows the lowest absolute values, but the highest percentage of acid particulate when related to either total suspended particulate or sulfate.

Respirable Dust Fraction

Suspended particulate material in the atmosphere is never of uniform particle size. The distribution of sizes of particles varies from one situation to another, and from one time to another. The composition of the material, the source and manner of its generation, the time elapsed since generation, and meteorological conditions are among the many factors that influence the size distribution of particles in the atmosphere.

Respiration carries airborne particles into the respiratory system. Larger particles, in general, are deposited in the upper respiratory system; small particles may pass through the upper respiratory passages and be deposited in the fine structure of the lungs. Particles of such size and characteristics that they can reach and be deposited in the deep portions of the lungs are identified as being

Table 8. CUMULATIVE PERCENT FREQUENCY OF OCCURRENCE
ACID PARTICULATE - (AS H_2SO_4) - BY HIGH-VOLUME SAMPLER

Station number	Station location	Operating period	No. obs	Concentration, µg/m^3												Geom std dev
				Min. value	Percent of time concentration is exceeded:							Max. value	Arith mean	Std dev	Geom mean	
					90	70	50	30	16	10	1					
001	Willowbrook	7/66-3/67	165	0	1	2	3	4	5	7	10	14	4	2	4	1.7
002	Roselle	7/66-3/67	145	0	1	2	3	5	6	7	10	16	5	2	4	1.8
003	Fairview	8/66-3/67	86	0	2	3	4	6	8	9	13	14	5	3	4	1.8
004	Ft. Hamilton	7/66-3/67	166	1	2	3	4	5	6	7	12	19	5	3	4	1.5
005	Raritan	7/66-3/67	128	1	1	3	4	5	7	9	20	31	5	4	4	1.8
006	Bayonne	7/66-3/67	113	1	2	3	5	6	8	9	12	22	6	3	5	1.9
007	Newark	7/66-3/67	94	1	2	3	4	6	8	9	16	28	6	3	5	1.8
014	121st Street	7/66-3/67	55	2	2	4	5	8	10	13	25	43	8	7	6	1.8
016	New Rochelle	7/66-3/67	152	1	2	3	4	5	7	8	14	14	5	3	4	1.7
021	Ancora	2/67-3/67	29	2	2	2	3	3	4	5	9	9	4	2	3	1.5
024	Lower Manhattan	2/67-3/67	25	4	4	4	6	8	10	10	13	12	7	3	7	1.5
025	Mid -Manhattan	2/67-3/67	15	5	5	7	9	10	12	13	14	14	9	3	8	1.4
095	Union City	2/67-3/67	32	3	3	5	6	7	8	9	10	13	6	2	6	1.4
101	Jersey City	2/67-3/67	35	2	3	4	5	7	8	9	12	14	6	3	6	1.5
108	Carteret	2/67-3/67	34	0	1	2	4	5	6	6	7	13	5	3	4	1.9
132	Perth Amboy	2/67-3/67	31	0	1	2	4	5	7	8	11	11	5	3	4	1.8

Table 9. SEASONAL ARITHMETIC AND GEOMETRIC MEANS ACID PARTICULATE (AS H_2SO_4) - BY HIGH-VOLUME SAMPLER

Station number	Station location	Arithmetic mean, $\mu g/m^3$			Geometric mean, $\mu g/m^3$		
		July-Sept. 1966	Oct.-Dec. 1966	Jan.-Mar. 1967	July-Sept. 1966	Oct.-Dec. 1966	Jan.-Mar. 1967
001	Willowbrook	4	4	5	3	3	4
002	Roselle	4	4	5	3	3	4
003	Fairview	4	5	6	4	5	5
004	Ft. Hamilton	3	5	6	4	4	5
005	Raritan	4	5	6	3	4	5
006	Bayonne	4	6	6	4	5	5
007	Newark	5	6	6	4	5	5
014	121st Street	5	7	14	4	6	11
016	New Rochelle	5	5	6	4	4	5
021	Ancora	-	-	3	-	-	3
024	Lower Manhattan	-	-	4	-	-	4
025	Mid-Manhattan	-	-	9	-	-	9
095	Union City	-	-	6	-	-	6
101	Jersey City	-	-	6	-	-	5
108	Carteret	-	-	2	-	-	3
132	Perth Amboy	--	-	5	-	-	3

Table 10. PERCENT ACID PARTICULATE OF TOTAL SUSPENDED PARTICULATE AND OF SULFATE PARTICULATE[a] - BY HIGH-VOLUME SAMPLER

Station number	Station location	Total particulate, $\mu g/m^3$	Acid particulate, $\mu g/m^3$	Acid particulate, percent of total	Sulfate particulate, $\mu g/m^3$	Acid particulate, percent of sulfate
001	Willowbrook	95	4	4	20	20
002	Roselle	97	5	5	17	29
003	Fairview	122	5	4	19	26
004	Ft. Hamilton	78	5	6	19	26
005	Raritan	80	5	6	18	28
006	Bayonne	98	6	6	22	27
007	Newark	156	6	4	20	30
014	121st Street	144	8	6	25	32
016	New Rochelle	91	5	5	18	28
021	Ancora	45	4	9	11	36
024	Lower Manhattan	103	7	7	22	32
025	Mid -Manhattan	129	9	7	26	35
095	Union City	117	6	5	20	30
101	Jersey City	125	6	5	25	24
108	Carteret	108	5	5	24	21
132	Perth Amboy	96	5	5	19	26

[a] Determined from the arithmetic averages for July 1966 through March 1967.

respirable. After review of available scientific evidence on pulmonary deposition of particulates, the Office of Health and Safety, U.S. Atomic Energy Commission, defined the size distribution of respirable particulates as follows:[4]

Equivalent Size, microns	Percent Respirable
≥10	0
5	25
3.5	50
2.5	75
≤ 2	100

The equivalent size of a particle is the diameter of a unit density sphere that has the same aerodynamic behavior as that particle.

A cyclone collector that simulates the particle collection characteristics of the upper respiratory system is commercially available. The equivalent size distribution of particles retained on a filter following such a collector agrees closely with that defined as respirable. Three stations in the survey area were equipped with two-stage cyclone-filter devices for collection of samples to represent the respirable fraction of the suspended particulate matter. The stations were selected to represent an industrialized zone, Newark (No. 007); a high-population-density zone, 121st Street, Manhattan (No. 014); and a residential area, Willowbrook (No. 001).

Table 11 lists the data obtained to represent the repirable portion of the suspended particulate. Although the lowest average value for respirable dust was found in the residential area, Willowbrook, the relative concentration as percent of total suspended particulate, is the highest, an average of 63 percent. The greatest values for respirable material were found in samples from the heavily populated area in Manhattan represented by the 121st Street station (No. 014.). Respirable material at this station averaged about one-half of the total suspended particulate. The heavy industrial area, Newark, shows the highest average concentration of total suspended particulate, but the lowest fraction as respirable, an average of 44 percent. Comparison of total suspended particulate at Willowbrook to that in Newark, yeilds a ratio of 1 to 1.7 the corresponding ratio for respirable dust is 1 to 1.1 (Figure 4). People living in residential areas are thus exposed to repirable dust concentrations that are more nearly equal to those of a heavily industrialized area than would be indicated by total suspended particulate data alone. The maximum respirable dust value observed was 123 $\mu g/m^3$ at the 121st Street station (No. 014.). The fourth highest value, 99 $\mu g/m^3$, was obtained in the residential area at Willowbrook.

TABLE 11. CLASSIFICATION OF SUSPENDED PARTICULATE MATERIAL BY SIZE, ESTIMATED RESPIRABLE CONCENTRATIONS

(Monthly Averages)

	Date	No. of Obs.	Total Particulate ug/m^3	Respirable Particulate ug/m^3	Percent Respirable
Station 001	April '67	3	37	21	57
(Willowbrook)	May '67	1	100	67	67
	June '67	5	113	71	63
	July '67	7	101	62	61
	Aug.'67	5	100	68	68
	Sept.'67	8	82	54	66
	Oct. '67	8	74	44	59
Arith.Mean			87	55	63
Station 007	June '67	4	163	77	47
(Newark)	July '67	4	239	73	31
	Aug. '67	9	132	65	49
	Sept '67	4	103	52	50
	Oct. '67	5	116	51	44
Arith. Mean			145	63	44
Station 014	June '67	5	171	80	47
(121st Street)	July '67	10	152	82	54
	Aug. '67	7	127	55	43
	Sept. '67	5	88	42	48
	Oct. '67	4	112	55	49
Arith. Mean			134	66	49

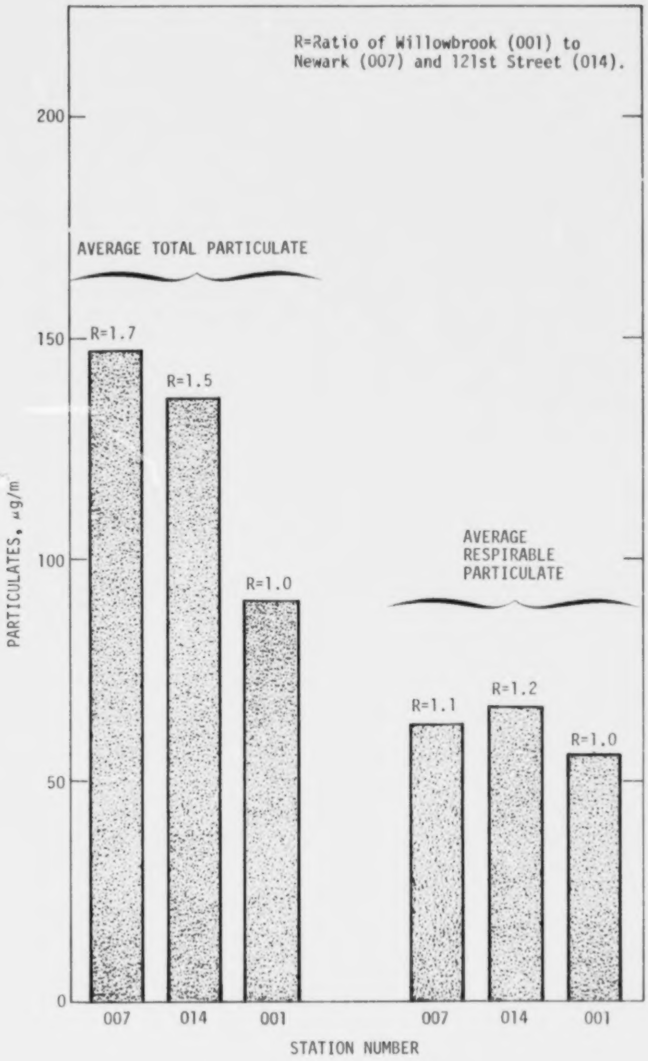

Figure 4. Comparison of total suspended particulate to respirable particulate.

Suspended Particulate Metals

The National Air Sampling Network compiled data on metals content of suspended particulate since 1961 on two locations in the study area, 121st Street in Manhattan and Newark. Data obtained from these analyses are given in Tables 12 and 13.

Table 12. CUMULATIVE PERCENT FREQUENCY OF OCCURRENCE OF SUSPENDED PARTICULATE METALS - BY HIGH-VOLUME SAMPLER - NASN DATA

Station metal	No. of values	Concentration, $\mu g/m^3$									Std geo dev
		Min. value	Percent of time concentration is exceeded:					Max. value	Arith mean	Geo mean	
			90	70	50	30	10				
121st Street (014) - Operation period: 1962-1964											
Chromium	75	-	-	0.011	0.012	0.019	0.035	0.078	0.016	0.007	5.05
Copper	75	0.02	0.03	0.05	0.08	0.12	0.25	0.38	0.11	0.09	2.08
Iron	75	0.4	0.5	0.9	1.3	1.9	3.8	6.2	1.7	1.4	1.94
Lead	75	0.1	0.4	0.8	1.2	1.7	3.0	6.0	1.5	1.1	2.15
Manganese	75	-	0.01	0.02	0.03	0.04	0.07	0.13	0.04	0.03	2.02
Nickel	75	0.025	0.052	0.090	0.119	0.164	0.248	0.460	0.140	0.119	1.80
Tin	75	-	-	0.01	0.02	0.04	0.08	0.17	0.04	0.03	2.42
Titanium	75	0.01	0.01	0.02	0.03	0.05	0.08	0.15	0.04	0.03	2.01
Vanadium	75	0.110	0.142	0.241	0.374	0.493	0.870	2.20	0.442	0.355	1.93
Zinc	75	-	0.01	0.38	0.61	0.90	1.66	2.80	0.70	0.32	6.78
Newark[a] - Operating period: 1961-1964											
Chromium	51	-	0.010	0.015	0.026	0.026	0.052	0.130	0.033	0.023	2.80
Copper	51	0.01	0.03	0.05	0.09	0.14	0.29	0.57	0.13	0.09	2.33
Iron	51	0.3	0.5	0.8	1.3	1.8	2.6	17.0	1.7	1.3	1.99
Lead	51	0.2	0.4	0.5	0.7	1.7	2.8	3.8	1.3	0.9	2.21
Manganese	51	0.01	0.01	0.01	0.02	0.04	0.06	0.48	0.04	0.03	2.26
Nickel	51	0.009	0.034	0.045	0.084	0.102	0.141	0.340	0.087	0.069	2.02
Tin	51	-	-	0.01	0.01	0.03	0.05	0.14	0.03	0.02	2.58
Titanium	51	0.01	0.01	0.02	0.03	0.04	0.08	0.45	0.05	0.03	2.08
Vanadium	51	0.023	0.081	0.144	0.177	0.287	0.526	0.720	0.244	0.194	2.04
Zinc	51	-	0.01	0.26	0.46	0.63	1.26	4.50	0.67	0.27	6.51

[a] Data from NASN station at Newark City Hall, 920 Broad Street.

Table 13. ANALYSES OF SUSPENDED PARTICULATE METALS BY HIGH-VOLUME SAMPLER - NASN DATA
(micrograms/cubic meter)

			Antimony		Beryllium[a]		Bismuth		Cadmium		Cobalt		Molybdenum	
Station location	Years	No. of samples	Samples showing antimony	Max. value	Samples showing beryllium	Max. value	Samples showing bismuth	Max. value	Samples showing cadmium	Max. value	Samples showing cobalt	Max. value	Samples showing molybdenum	Max. value
New York (014)	1962	25	0	0.000	0	-	9	0.004	17	0.180	0	0.000	16	0.02
	1963	24	0	0.000	0	-	15	0.004	8	0.064	0	0.000	11	0.01
	1964	26	0	0.000	0	-	7	0.002	8	0.040	0	0.000	10	0.02
Newark[b]	1961	25	1	0.039	1	0.001	1	0.002	12	0.120	0	0.000	8	0.02
	1962	-	-	-	0	-	-	-	-	-	-	-	-	-
	1964	26	0	0.000	0	-	1	0.001	13	0.350	0	0.000	3	0.01

[a] 1963 values for beryllium based on 25 samples.

[b] **Data from NASN station at Newark City Hall, 920 Broad Street.**

Table 14 compares these data to the national arithmetic average as given by the National Air Sampling Network.[3] Lead values for the study area samples are approximately twice the national average; nickel is 3 to 4 times higher, vanadium is 5 to 8 times higher; the other metals are approximately the same as the national averages.

Table 14. COMPARISON OF SUSPENDED PARTICULATE METALS DATA WITH NATIONAL AIR SAMPLING NETWORK AVERAGES

Station location	Arithmetic mean		
	Newark[a]	121st Street	Average NASN
Chromium	0.033	0.016	0.015
Copper	0.13	0.11	0.09
Iron	1.7	1.7	1.58
Lead	1.3	1.5	0.79
Manganese	0.04	0.04	0.10
Nickel	0.087	0.140	0.034
Tin	0.03	0.04	0.02
Titanium	0.05	0.04	0.04
Vanadium	0.244	0.442	0.05
Zinc	0.67	0.70	0.67

[a] Data from NASN station at Newark City Hall, 920 Broad Street.

Suspended Particulate - AISI Sampler

Soiling index of particulate pollutants as sampled by the AISI tape sampler was measured at seven sampling sites. At Newark (No. 007) and New Rochelle (No. 016), readings were obtained at hourly intervals; all other stations operated with 2-hour sampling intervals. Periods of sample collection varied from station to station, with three of them operating for 16 months, two for approximately 1 year, and two for less than 6 months. As in the sampling for suspended particulates by the high-volume sampler, Ancora (No. 021) was used to obtain background data.

Soiling values obtained from 31,732 measurements ranged from a low of less than 0.1 Coh* per 1,000 lineal feet to a high of 10.2 Coh per 1,000 lineal feet (See Table 15). Newark (No. 007) gave the highest value with 50 percent of the data above 2.6 Cohs. Five of the six urban stations had values in excess of 1.0 Coh more than 50 percent of the time.

Table 16 gives the percent of time that the daily average value for each station was observed to be within a given range. Newark (No. 007) has the highest occurrences of heavy soiling particulate; the daily average values fall within the range of 2.0 to 2.9 Cohs 44 percent of the time, 3.0 to 3.9 Cohs 30 percent of the time, and 4.0 or more Cohs 9 percent of the time. These ranges are rated from heavy to extremely heavy soiling. The station next in rank is 121st Street in Manhattan (No. 014).

Seasonal variations, as shown in Table 17, are more pronounced for soiling index than for the other parameters measured for particulate pollution. Bayonne (No. 006), New York University (No. 012), Central Park (No. 013) and 121st Street (No. 014) stations yielded winter values about twice as great as those of the summer. Other stations show differences of a lesser degree, with Newark (No. 007) and Ancora (No. 021) showing fall values higher than those in other seasons.

Diurnal variations are given in Figure 5. Generally, highest values are experienced between the hours of 7 and 8 a.m., with the next highest values found between 5 and 8 p.m.

Settleable Particulate - Dustfall

Settleable particulate was collected at 39 sites from January 1966 to June 1967. Dustfall data were obtained from the City of New York Air Pollution Control Department for eight of these sites and for 16 other sites for the period extending back to January 1964. Data are therefore reported for 55 sites.

Frequency distributions of the monthly concentration values are given in Table 18. Thirty-four of the 55 stations (62 percent) show concentration values equal to or greater than 25 tons per square mile per month 50 percent of the time. For extreme values, 23 (42 percent) of the stations exceed 35 tons per square mile per month half the time. Maximum values were experienced in Manhattan, where concentrations in excess of 100 tons per square mile per month were reported about 10 percent of the time. Rural stations in May's Landing (No. 001E), Long Island (No. 019E), and White Plains (No. 020E) yielded data having 50th percentile values in the range of 6 to 8 tons per square mile per month.

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* Coefficient of haze - see Appendix B.

Table 15. CUMULATIVE PERCENT FREQUENCY OF OCCURRENCE OF BI HOURLY SOILING INDEX AVERAGES

Station number	Station location	Operating period	No.of obs	Soiling index, Cohs/1,000 lineal feet										
				Min. value	Percent of time concentration is exceeded:							Max. value	Arith. mean	Std dev
					90	70	50	30	16	10	1			
006	Bayonne	6/66-4/67	3257	0.0	0.4	0.6	0.8	1.2	1.7	2.1	3.9	9.4	1.0	0.8
007	Newark[a]	5/66-4/67	8139	0.0	1.4	2.0	2.6	3.3	4.0	4.5	6.6	10.2	2.8	1.3
012	N.Y. University	1/66-4/67	5559	0.0	0.4	0.8	1.2	1.8	2.5	3.0	5.3	9.6	1.5	1.1
013	Central Park	1/66-4/67	5283	0.0	0.3	0.9	1.3	1.8	2.4	2.8	4.7	7.4	1.5	1.0
014	121st Street	1/66-4/67	5445	0.1	0.8	1.3	1.8	2.5	3.2	3.7	6.1	9.8	2.1	1.1
016	New Rochelle[a]	6/66-2/67	2155	0.2	0.6	0.9	1.2	1.6	2.0	2.3	3.4	5.4	1.2	0.6
021	Ancora	11/66-4/67	1894	0.0	0.1	0.2	0.4	0.6	0.9	1.0	2.0	3.2	0.5	0.4

[a] Hourly observations.

Table 16. PERCENT OF DAYS, DAILY AVERAGE VALUES WERE OBSERVED WITHIN GIVEN RANGE, SUSPENDED PARTICULATE (SOILING) - BY AISI SAMPLER

Cohs/1000 lineal ft	006 Bayonne	007 Newark	012 N.Y.U.	013 Central Park	014 Manhattan, 121st St.	016 New Rochelle	021 Ancora
0.0 - 0.4	14	0	3	5	<1	4	52
0.5 - 0.9	42	<1	23	20	7	28	38
1.0 - 1.9	36	16	46	53	44	60	10
2.0 - 2.9	6	44	18	17	31	8	0
3.0 - 3.9	1	30	7	4	11	0	0
4.0 plus	<1	9	3	< 1	6	0	0

Table 17. SEASONAL GEOMETRIC AND ARITHMETIC MEANS SUSPENDED PARTICULATE (SOILING) - BY AISI SAMPLER

(Cohs/1000 lineal ft)

Station number	Station location	Arithmetic mean				Geometric mean			
		Summer 1966	Fall 1966	Winter 1967	Spring 1967	Summer 1966	Fall 1966	Winter 1967	Spring 1967
006	Bayonne	0.6	1.1	1.3	1.1	0.6	0.9	1.1	1.0
007	Newark	2.7	3.3	2.7	2.2	2.6	3.1	2.5	2.1
012	N.Y. University	1.1	1.8	2.0	1.6	1.0	1.5	1.8	1.4
013	Central Park	1.0	1.6	1.9	1.4	0.9	1.4	1.7	1.4
014	121st Street	1.4	2.4	2.7	2.0	1.3	2.3	2.3	1.8
016	New Rochelle	1.0	-	1.4	-	0.9	-	1.3	-
021	Ancora	-	0.7	0.5	0.4	-	0.5	0.4	0.4

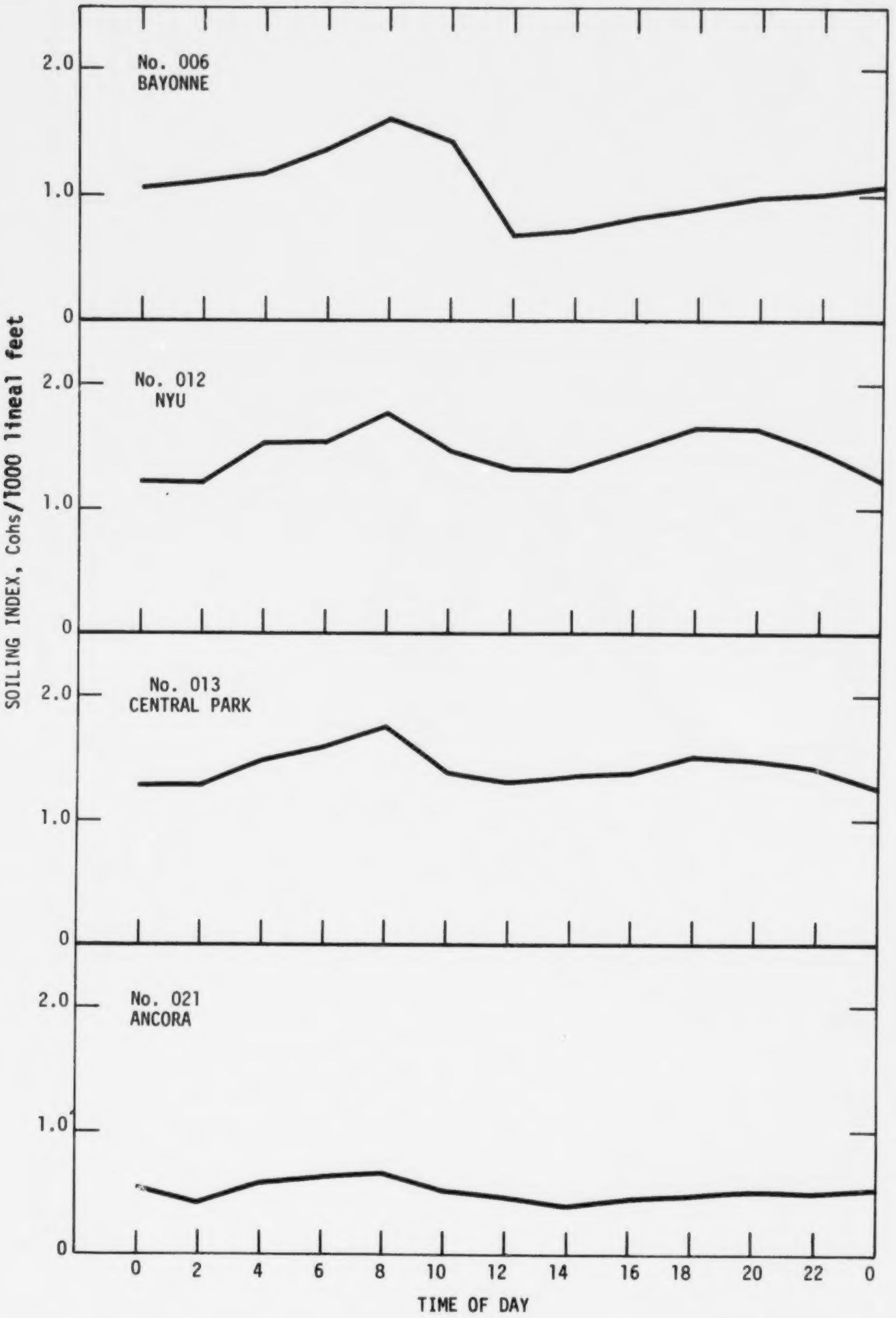

Figure 5a. Diurnal variation of soiling index (suspended particulate) measured by AISI sampler at stations 006, 012, 013, and 021.

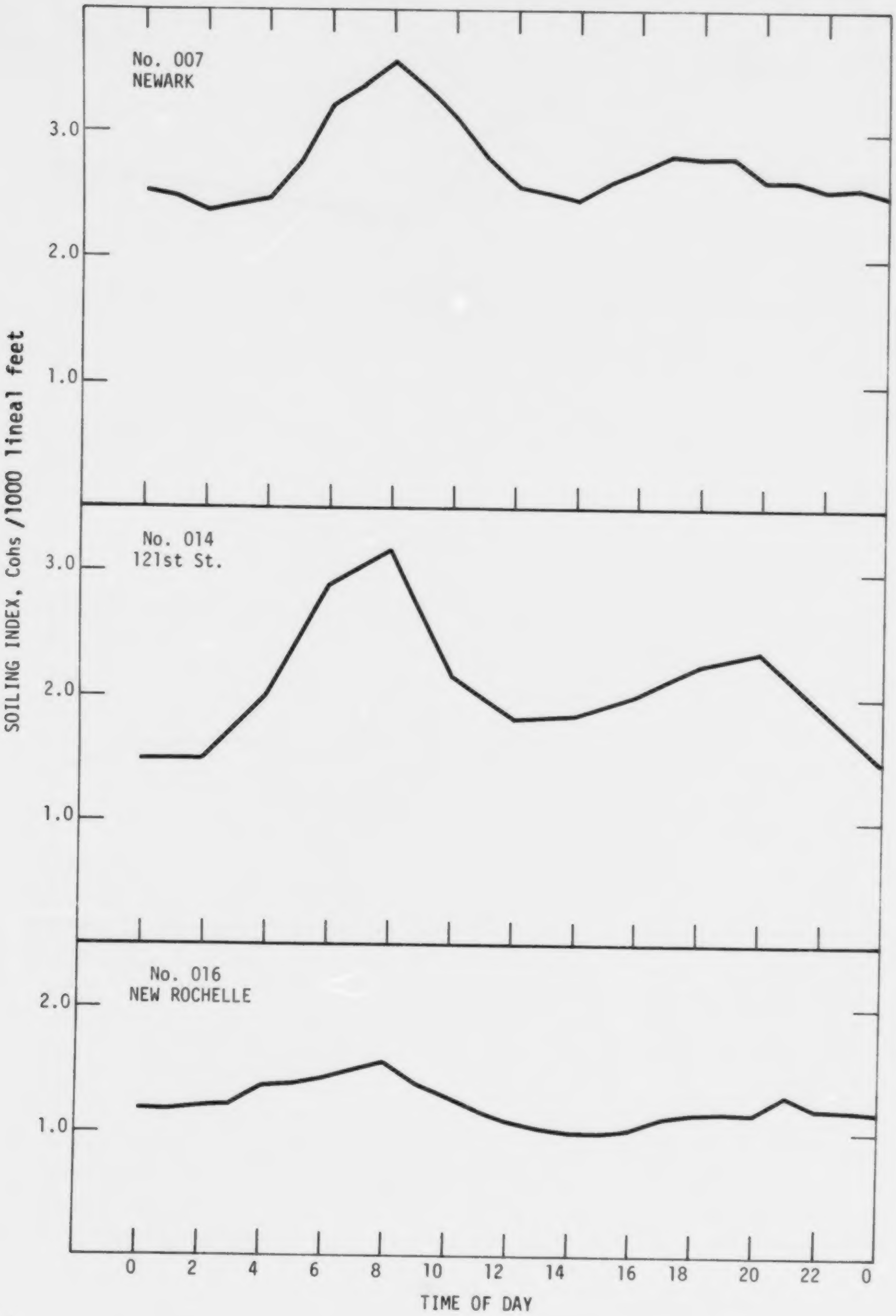

Figure 5b. Diurnal variation of soiling index (suspended particulate) measured by AISI sampler at stations 007, 014, and 016.

TABLE 18. CUMULATIVE PERCENT FREQUENCY OF OCCURRENCE OF MONTHLY AVERAGES SETTLEABLE PARTICULATE - DUSTFALL

				Dustfall, tons/mi^2-Mo.											
					Percent of time concentration is exceeded:										
Station number	Station location	Operating Period	No. of Obs.	Min value	90	70	50	30	16	10	Max value	Arith mean	Std dev	Geom mean	Geom std dev
013	Central Park	1/66-9/67	18	15	22	28	34	41	48	52	57	34	11	34	1.4
014	121st Street	1/64-2/66	25	34	44	62	78	98	120	135	147	85	32	79	1.4
022	Bronx[a]	1/64-9/67	43	19	28	39	49	59	68	72	85	48	15	47	1.4
026	Queens[a]	1/64-9/67	40	21	28	41	53	68	83	92	116	56	23	53	1.6
028	Staten Island	1/66-4/67	16	12	16	18	20	23	25	26	28	22	4	21	1.2
033	Manhattan	3/66-9/67	17	18	21	30	37	44	50	53	58	37	13	37	1.4
034	Bronx	1/66-9/67	17	12	15	22	27	32	36	39	40	26	9	27	1.3
035	Bronx[a]	1/64-9/67	43	13	21	27	32	38	44	48	54	33	10	32	1.4
037	Queens	3/66-9/67	17	13	13	18	23	29	34	37	44	24	10	23	1.5
039	Queens	7/66-9/67	13	13	14	18	22	32	41	45	48	25	11	22	1.9
040	Queens	7/66-9/67	12	12	12	15	19	25	33	37	44	21	9	19	1.7
116	Queens	3/66-4/67	13	11	11	14	16	18	21	22	25	16	4	16	1.3
118	Manhattan	1/66-9/67	19	15	21	26	31	37	44	47	54	33	10	31	1.4
119	Queens	3/66-9/67	17	16	16	21	26	31	37	41	48	28	5	26	1.4
120	Queens	3/66-9/67	16	8	10	13	16	19	21	23	25	16	5	16	1.3
121	Brooklyn[a]	3/64-9/67	40	16	22	30	37	46	56	62	134	41	21	37	1.5
122	Brooklyn	4/66-9/67	16	15	16	21	24	28	33	35	37	25	5	24	1.4
123	Brooklyn	3/66-9/67	16	17	17	24	30	37	45	50	90	32	17	30	1.3
124	Brooklyn	3/66-9/67	16	13	15	18	22	26	30	32	35	23	5	22	1.4

[a] Additional data obtained from New York City - Department of Air Pollution Control for years 1964-65.

TABLE 18 (CONT'D). CUMULATIVE PERCENT FREQUENCY OF OCCURRENCE OF MONTHLY AVERAGES SETTLEABLE PARTICULATE - DUSTFALL

Station number	Station location	Operating period	No. of Obs.	Dustfall, tons/mi^2-Mo.											Geom std dev
				Min value	Percent of time concentration is exceeded:						Max value	Arith mean	Std dev	Geom mean	
					90	70	50	30	16	10					
125	Brooklyn	4/66-9/67	16	11	16	19	22	25	27	29	32	22	5	22	1.2
128	Staten Island	4/66-9/67	16	11	12	14	16	18	19	20	20	16	4	16	1.2
130	Staten Island[a]	1/64-9/67	40	15	16	21	26	31	37	42	55	28	5	26	1.4
140	Bronx[a]	2/64-9/67	41	14	20	29	38	50	64	73	105	42	6	38	1.7
141	Bronx	3/66-9/67	17	10	13	17	20	24	28	30	34	21	4	20	1.4
142	Brooklyn[a]	1/64-9/67	42	21	27	40	51	66	82	92	116	55	24	51	1.6
143	Brooklyn	3/66-9/67	17	13	15	19	23	27	30	31	31	23	5	23	1.3
144	Manhattan	3/66-9/67	13	29	30	40	50	62	72	76	76	51	7	50	1.4
145	Manhattan[a]	1/64-9/67	43	23	32	45	55	69	84	92	128	60	25	55	1.5
147	Staten Island	3/66-9/67	15	16	17	21	24	28	32	34	40	24	6	24	1.3
148	Staten Island	3/66-9/67	17	12	13	15	18	22	25	27	28	19	5	18	1.4
149	Staten Island	1/64-9/67	23	14	17	24	30	39	47	51	68	33	15	30	1.6
150	Manhattan[a]	1/64-2/66	25	54	55	67	78	90	102	110	150	84	22	82	1.3
151	Manhattan[a]	1/64-2/66	25	29	50	63	74	86	100	109	121	77	22	74	1.4
153	Manhattan[a]	1/64-2/66	25	33	42	48	60	70	80	86	106	63	16	61	1.3
154	Manhattan[a]	1/64-2/66	26	32	34	39	47	61	82	102	143	60	31	55	1.5
156	Brooklyn[a]	1/64-2/66	26	42	42	54	62	78	90	100	121	68	22	65	1.4
157	Brooklyn[a]	1/64-2/66	26	37	42	53	62	74	86	94	112	66	19	64	1.3
158	Brooklyn[a]	1/64-2/66	23	33	42	49	56	62	76	84	86	60	15	58	1.3

[a] Additional data obtained from New York City-Department of Air Pollution Control for years 1964-65.

TABLE 18 (CONT'D). CUMULATIVE PERCENT FREQUENCY OF OCCURRENCE OF MONTHLY AVERAGES

SETTLEABLE PARTICULATE - DUSTFALL

Station number	Station location	Operating period	No. of Obs.	Dustfall, tons/mi^2-Mo.											Geom std dev
				Min value	Percent of time concentration is exceeded:						Max value	Arith mean	Std dev	Geom mean	
					90	70	50	30	16	10					
159	Queens[a]	1/64-2/66	21	28	44	52	58	66	72	78	89	62	15	60	1.3
160	Queens[a]	1/64-2/66	25	32	35	41	45	50	55	59	73	49	10	48	1.2
161	Queens[a]	1/64 2/66	24	33	37	41	45	49	54	58	63	49	8	48	1.2
162	Queens[a]	1/64-2/66	25	19	20	26	31	36	40	43	84	36	18	33	1.5
163	Queens[a]	1/64-2/66	24	15	19	27	35	43	50	56	67	36	14	33	1.5
166	Bronx[a]	2/64-2/66	25	20	22	27	31	34	37	38	70	34	9	33	1.3
167	Staten Island[a]	1/64-2/66	26	25	26	32	36	41	45	47	59	39	10	38	1.2
168	Staten Island[a]	1/64-2/66	26	14	18	25	30	35	40	43	51	33	10	31	1.4
169	Staten Island[a]	1/64-3/66	26	21	21	29	35	41	46	50	52	35	9	34	1.3
001E	May's Landing[b]	6/66-9/67	16	2	2	3	5	8	11	14	33	8	7	5	2.2
002E	Perth Amboy[b]	6/66-9/67	16	9	10	15	19	23	26	29	36	19	7	19	1.4
003E	Elizabeth[b]	6/66-9/67	16	11	12	18	22	27	30	31	32	23	7	22	1.4
004E	Staten Island[b]	6/66-9/67	14	5	6	9	11	15	19	22	36	13	9	11	1.7
005E	Brooklyn[b]	6/66-9/67	16	8	28	41	54	70	88	98	124	59	33	54	1.6
019E	Long Island[b]	6/66-9/67	16	4	4	6	8	11	15	17	29	10	6	8	1.9
020E	White Plains[b]	6/66-9/67	16	1	3	5	7	9	12	14	19	8	5	7	1.7
021E	Greenwich,Conn[b]	6/66-9/67	16	6	7	9	12	14	17	18	23	12	4	12	1.4

[a] Additional data obtained from New York City-Department of Air Pollution Control for years 1964-65.

[b] Additional data obtained from Surveillance Project Sites.

Seasonal variations are given in Table 19. Generally, higher values are observed in the winter season, with lower values in the summer. On an annual basis there appears to be a trend toward lower concentrations when data for the years 1964-66 are compared.

Table 20 lists the percent of time that specific concentrations were exceeded at various stations. Of the 55 stations, 42 exceeded concentration values of 30 tons per square mile per month at least 10 percent of the time.

In addition to the 55 dustfall stations discussed above, measurements were obtained at 27 New Jersey stations. These data are listed in Table 21. No analysis of these limited data was possible; however, the results were considered in the iso-intensity plot, which appears on page 85, showing the impact of settleable particulate on the study area.

TABLE 19. SEASONAL ARITHMETIC MEAN SETTLEABLE PARTICULATE - DUSTFALL
(tons/mi^2-Mo.)

Station number	Station location	Arithmetic mean																		
		1964					1965					1966					1967		
		Jan-Mar.	Apr-June	July Sept.	Oct-Dec.	Year	Jan-Mar.	Apr-June	July Sept.	Oct-Dec.	Year	Jan-Mar.	Apr-June	July-Sept.	Oct-Dec.	Year	Jan-Mar.	Apr-June	July Sept.
013	Central Park	-	-	-	-	-	-	-	-	-	-	42	39	28	31	35	37	33	27
014	121st Street	128	95	76	113	103	100	78	66	44	72	51	-	-	-	-	-	-	-
022	Bronx[a]	64	57	60	63	61	71	48	48	42	52	43	34	25	39	35	48	37	26
026	Queens[a]	86	90	74	74	81	82	68	60	47	64	59	38	27	36	40	43	37	25
028	Staten Island	-	-	-	-	-	-	-	-	-	-	25	18	20	20	21	23	-	-
033	Manhattan	-	-	-	-	-	-	-	-	-	-	-	32	28	44	-	54	38	23
034	Bronx	-	-	-	-	-	-	-	-	-	-	-	21	18	28	-	38	27	17
035	Bronx[a]	43	41	56	35	44	43	42	34	35	39	30	24	21	25	25	32	25	18
037	Queens	-	-	-	-	-	-	-	-	-	-	-	21	17	24	-	41	21	15
039	Queens	-	-	-	-	-	-	-	-	-	-	-	-	15	21	-	39	22	25
040	Queens	-	-	-	-	-	-	-	-	-	-	-	-	17	19	-	38	24	14
116	Queens	-	-	-	-	-	-	-	-	-	-	-	15	13	15	-	24	-	-
118	Manhattan	-	-	-	-	-	-	-	-	-	-	44	30	26	34	34	42	34	22
119	Queens	-	-	-	-	-	-	-	-	-	-	-	24	20	31	-	41	26	19
120	Queens	-	-	-	-	-	-	-	-	-	-	-	14	12	14	-	36	14	14
121	Brooklyn[a]	-	-	-	-	-	-	-	-	-	-	-	28	22	26	-	36	31	25
122	Brooklyn	-	-	-	-	-	-	-	-	-	-	-	26	20	26	-	35	26	18
123	Brooklyn	-	-	-	-	-	-	-	-	-	-	-	30	25	34	-	52	32	19
124	Brooklyn	-	-	-	-	-	-	-	-	-	-	-	28	16	24	-	30	22	15
125	Brooklyn	-	-	-	-	-	-	-	-	-	-	-	24	22	21	-	23	30	18
128	Staten Island	-	-	-	-	-	-	-	-	-	-	-	18	15	15	-	15	18	19
130	Staten Island[a]	37	36	36	37	37	35	36	30	19	30	22	19	18	20	20	20	23	20

[a] Additional data obtained from New York City-Department of Air Pollution Control for years 1964-65.

- No data available.

Table 19 (Continued). SEASONAL ARITHMETIC MEAN SETTLEABLE PARTICULATE - DUSTFALL
(tons/mi^2-Mo.)

Station number	Station location	Arithmetic mean																	
		1964					1965					1966					1967		
		Jan-Mar	Apr-June	July-Sept.	Oct-Dec.	Year	Jan-Mar.	Apr-June	July-Sept.	Oct-Dec.	Year	Jan-Mar.	Apr-June	July Sept.	Oct-Dec.	Year	Jan-Mar.	Apr-June	July-Sept.
140	Bronx [a]	57	58	44	71	58	62	69	47	35	53	39	26	19	27	28	33	23	20
141	Bronx	-	-	-	-	-	-	-	-	-	-	-	17	17	26	-	28	20	15
142	Brooklyn [a]	94	77	65	94	83	74	63	47	45	57	56	32	29	35	38	51	38	26
143	Brooklyn	-	-	-	-	-	-	-	-	-	-	-	24	16	23	-	28	26	18
144	Manhattan	-	-	-	-	-	-	-	-	-	-	-	31	31	59	-	72	59	38
145	Manhattan[a]	111	74	63	87	84	100	56	51	49	64	58	36	32	43	42	60	49	26
147	Staten Island	-	-	-	-	-	-	-	-	-	-	-	26	24	21	-	35	26	20
148	Staten Island	-	-	-	-	-	-	-	-	-	-	-	17	15	19	-	26	18	17
149	Staten Island	-	-	-	-	-	-	-	-	-	-	-	-	26	19	-	22	30	25
150	Manhattan [a]	114	82	75	82	88	105	76	64	59	76	85	-	-	-	-	-	-	-
151	Manhattan [a]	92	89	68	89	85	102	60	66	47	69	92	-	-	-	-	-	-	-
153	Manhattan [a]	88	67	62	61	70	68	47	48	59	56	68	-	-	-	-	-	-	-
154	Manhattan [a]	121	90	41	41	73	48	46	43	37	44	64	-	-	-	-	-	-	-
156	Brooklyn [a]	103	74	54	79	78	86	54	47	47	59	68	-	-	-	-	-	-	-
157	Brooklyn [a]	95	71	52	62	70	78	63	48	51	60	61	-	-	-	-	-	-	-
158	Brooklyn [a]	76	53	51	76	64	71	47	51	40	52	54	-	-	-	-	-	-	-
159	Queens [a]	83	61	67	67	70	66	59	52	45	56	41	-	-	-	-	-	-	-
160	Queens [a]	64	53	41	52	53	48	43	36	48	44	50	-	-	-	-	-	-	-
161	Queens [a]	54	44	46	45	47	50	50	46	39	46	48	-	-	-	-	-	-	-
162	Queens [a]	36	57	30	36	40	38	25	22	26	28	55	-	-	-	-	-	-	-
163	Queens [a]	50	35	40	30	39	38	42	23	23	32	46	-	-	-	-	-	-	-

[a] Additional data obtained from New York City-Department of Air Pollution Control for years 1964-65.

- No data available.

Table 19 (Continued). SEASONAL ARITHMETIC MEAN SETTLEABLE PARTICULATE - DUSTFALL

tons/mi^2-mo.

Station number	Station location	Arithmetic mean																	
		1964					1965					1966					1967		
		Jan-Mar	Apr-June	July-Sept.	Oct-Dec.	Year	Jan-Mar	Mar-June	July-Dept.	Oct-Dec.	Year	Jan-Mar.	Apr-June	July-Sept.	Oct-Dec.	Year	Jan-Mar.	Apr-June	July-Sept.
166	Bronx[a]	32	32	32	33	32	44	36	33	27	35	27	-	-	-	-	-	-	-
167	Staten Island[a]	40	47	44	39	43	40	38	38	29	36	36	-	-	-	-	-	-	-
168	Staten Island[a]	32	41	43	38	39	32	30	23	21	27	23	-	-	-	-	-	-	-
169	Staten Island[a]	33	48	43	43	42	32	30	30	24	29	32	-	-	-	-	-	-	-
001E	May's Landing[b]	-	-	-	-	-	-	-	-	-	-	-	13	16	5	-	5	6	6
002E	Perth Amboy [b]	-	-	-	-	-	-	-	-	-	-	-	11	17	15	-	26	21	19
003E	Elizabeth[b]	-	-	-	-	-	-	-	-	-	-	-	14	19	24	-	30	15	19
004E	Staten Island[b]	-	-	-	-	-	-	-	-	-	-	-	8	18	9	-	9	18	11
005E	Brooklyn [b]	-	-	-	-	-	-	-	-	-	-	-	33	30	66	-	105	65	39
019E	Long Island [b]	-	-	-	-	-	-	-	-	-	-	-	6	11	7	-	18	11	7
020E	White Island [b]	-	-	-	-	-	-	-	-	-	-	-	9	9	7	-	4	9	10
021E	Greenwich,Conn.[b]	-	-	-	-	-	-	-	-	-	-	-	10	11	10	-	19	14	8

-No data available.

[a] Additional data obtained from New York City-Department of Air Pollution Control for years 1964-65.

[b] Additional data obtained from Surveillance Project Sites.

Table 20. PERCENT OF TIME CONCENTRATIONS EXCEEDED SPECIFIC VALUES SETTLEABLE PARTICULATE -DUSTFALL

Station number	Station location	tons/mi^2-Mo.			
		>20	>25	>30	>35
013	Central Park	89	78	67	39
014	Manhattan	100	100	100	96
022	Bronx	98	93	86	81
026	Queens	100	95	88	75
028	Staten Island	63	25	0	0
033	Manhattan	94	76	65	59
034	Bronx	65	47	35	24
035	Bronx	93	81	58	35
037	Queens	53	35	29	18
039	Queens	54	31	31	15
040	Queens	33	25	17	8
116	Queens	15	0	0	0
118	Manhattan	95	74	63	47
119	Queens	70	59	47	12
120	Queens	25	0	0	0
121	Brooklyn	92	82	65	52
122	Brooklyn	69	44	19	6
123	Brooklyn	81	69	38	19
124	Brooklyn	62	44	12	0
125	Brooklyn	75	19	6	0
128	Staten Island	6	0	0	0
130	Staten Island	70	48	40	25
140	Bronx	90	80	66	54
141	Bronx	53	18	12	0
142	Brooklyn	100	93	86	81
143	Brooklyn	65	41	6	0
144	Manhattan	100	100	92	62
145	Manhattan	100	95	93	86

TABLE 20.(CONT'D) PERCENT OF TIME CONCENTRATIONS EXCEEDED SPECIFIC VALUES SETTLEABLE PARTICULATE - DUSTFALL

Station number	Station location	tons/mi^2-Mo.			
		>20	>25	>30	>35
147	Staten Island	60	47	13	7
148	Staten Island	29	6	0	0
149	Staten Island	87	65	52	39
150	Manhattan	100	100	100	100
151	Manhattan	100	100	96	96
153	Manhattan	100	100	100	96
154	Manhattan	100	100	100	88
156	Brooklyn	100	100	100	100
157	Brooklyn	100	100	100	100
158	Brooklyn	100	100	100	96
159	Queens	100	100	95	95
160	Queens	100	100	100	88
161	Queen	100	100	100	96
162	Queens	92	75	58	33
163	Queens	96	70	61	43
166	Queens	100	92	60	32
167	Staten Island	100	93	73	58
168	Staten Island	93	69	46	42
169	Staten Island	100	77	62	50
001E	May's Landing	6	6	6	0
002E	Perth Amboy	31	19	6	6
003E	Elizabeth	56	50	12	0
004E	Staten Island	14	14	7	7
005E	Brooklyn	94	94	94	75
019E	Long Island	6	0	0	0
020E	White Plains	0	0	0	0
021E	Greenwich, Conn.	6	0	0	0

TABLE 21. SETTLEABLE PARTICULATE - DUSTFALL
(tons/mi^2-Mo.)

Station	Location	April 1967	May 1967	June 1967	July 1967	August 1967	September 1967	Arith. Mean
002	Roselle	17.4	17.4	11.5	16.0	15.5	7.6	14.2
003	Fairview	25.9	23.3	21.2	19.5	13.4	12.0	19.2
005	Raritan	10.6	14.6	9.2	11.0	9.9	5.5	10.1
006	Bayonne	40.6	30.8	59.2	19.9	24.2	12.3	31.2
007	Newark	64.1	53.9	34.3	41.0	51.7	27.2	45.4
021	Ancora	10.5	7.8	3.4	11.3	7.4	4.1	7.4
045	South Amboy	23.6	37.6	19.7	25.3	28.9	14.5	24.9
051	Scotch Plains	33.1	32.6	26.6	23.3	22.4	14.8	25.5
057	East Hanover	13.0	19.7	23.2	14.3	9.2	5.3	14.1
064	East Patterson	15.3	14.6	12.0	13.8	12.9	6.3	12.5
093	Rutherford	25.7	31.9	24.9	31.4	26.5	11.8	25.4
095	Union City	36.2	35.4	25.3	24.5	20.2	15.5	26.2
098	Kearney	11.4	30.5	48.0	33.3	21.0	15.0	26.5
100	Orange	6.7	17.6	13.7	15.1	18.0	7.0	13.0
101	Jersey City	45.8	62.6	36.6	26.2	24.6	24.7	36.8
104	Elizabeth	17.0	15.9	14.6	15.6	19.8	11.0	15.6
107	Rahway	17.1	44.6	1.1	14.5	15.7	-	18.6
108	Carteret	23.0	18.8	21.7	38.3	27.5	21.5	25.1
109	Sewaren	16.2	19.5	12.0	19.0	18.0	6.5	15.2
113	Old Bridge	11.1	25.6	12.9	11.7	14.5	7.1	14.6

Station	Location	January 1966	February 1966	March 1966	April 1966	May 1966	June 1966	July 1966	Arith Mean
024	Lower Manhattan	54.7	58.0	-	-	-	-	-	56.4
025	Mid Manhattan	43.7	-	-	-	-	-	-	
146	Queens	-	-	25.7	17.2	18.3	10.9	10.6	16.5
152	Manhattan	123.9	129.1	-	-	-	-	-	126.5
155	Manhattan	31.8	58.3	-	-	-	-	-	45.0
164	Queens	93.8	86.3	-	-	-	-	-	90.0
165	Queens	43.4	84.2	-	-	-	-	-	63.8

PARTICULATE EMISSION INVENTORY

An inventory of particulate emissions from the various sources in the 17-county New York - New Jersey area was completed for Calendar Year 1966. The survey included emissions from stationary fuel combustion sources, industrial processes, refuse burning, motor vehicles, aircraft, and ships.

Based on this survey, 231,000 tons of particulate are discharged to the atmosphere annually from sources in the study area. In Table 22, emissions are listed by source category for each county. These figures show that in the nine New Jersey counties 100,000 tons of particulate per year are generated (43 percent of the total). New York City contributes 95,600 tons per year (41 percent). The counties of Nassau, Rockland, and Westchester together account for 34,600 tons (15 percent), with emissions from the harbor areas accounting for the other 1,000 tons.

The 231,000 tons is principally solid particulate matter, but contains some finely divided liquid aerosols. These liquid aerosols include oil mists from a process such as asphalt blowing, and minute sulfuric and phosphoric acid particles from acid manufacturing plants. Solid particulates include both organics and inorganics from fuel combustion, charred cellulose and ash from incineration, oxidized gasoline additives (mainly lead compounds) from automobiles, mineral dust from rock crushing and handling and from asphaltic and Portland cement batching plants, metallurgical fume, petroleum catalyst fines, and miscellaneous organic and inorganic dusts from industrial processes.

Combustion of fuels at stationary sources represents the largest particulate source category. Emission from these sources represent 58 percent of the study area total as compared to 18 percent for refuse burning, 9 percent for industrial processes, and 15 percent for motor vehicles. Aircraft emissions, primarily from jet engines, and shipping emissions account for less than 1 percent of the total. The contributions of each source category and fuel type to the overall particulate emissions are shown in Tables 23 and 24 and in Figure 6.

Table 22. PARTICULATE EMISSIONS IN THE NEW YORK - NEW JERSEY STUDY AREA, 1966 (tons/year)

	Residential fuel						Commercial and governmental fuel					
	Coal		Oil				Coal		Oil			
	Bituminous	Anthracite	Distillate	Residual	Natural gas	Total	Bituminous	Anthracite	Distillate	Residual	Natural gas	Total
J-1 Bergen	151	1,363	1,213	18	195	2,940	394	21	100	438	67	1,020
J-2 Essex	159	1,478	1,497	65	138	3,337	746	32	211	1,071	64	2,124
J-3 Hudson	105	947	969	22	64	2,107	267	35	68	931	46	1,347
J-4 Middlesex	86	781	687	1	89	1,644	315	1	85	644	23	1,068
J-5 Monmouth	68	625	647	1	80	1,421	197	-	50	99	16	362
J-6 Morris	54	489	457	1	52	1,053	156	1	40	266	12	475
J-7 Passaic	75	677	584	7	82	1,425	197	11	50	345	24	627
J-8 Somerset	30	270	249	0	34	583	93	166	24	159	7	449
J-9 Union	95	864	852	12	90	1,913	241	9	61	669	21	1,001
New Jersey Total	823	7,494	7,155	127	824	16,423	2,606	276	689	4,622	280	8,473
Y-1 Bronx	111	2,109	733	1,305	75	4,332	175	726	286	388	28	1,603
Y-2 Brooklyn	67	2,595	2,677	1,410	295	7,044	110	1,176	847	1,086	63	3,282
Y-3 Staten Island	6	115	158	89	49	418	18	529	86	44	11	688
Y-4 Manhattan	161	3,070	102	2,411	48	5,792	175	1,125	182	534	71	2,087
Y-5 Queens	38	657	2,292	726	213	3,926	55	552	626	714	52	1,999
New York City Total	383	8,546	5,962	5,941	680	21,512	533	4,108	2,027	2,766	225	9,659
Y-6 Nassau	-	236	1,413	-	105	1,754	-	37	241	72	54	404
Y-7 Rockland	-	12	44	-	59	115	208	-	20	12	11	251
Y-8 Westchester	-	273	752	186	58	1,269	360	11	304	141	93	909
Outer New York Total	-	521	2,209	186	222	3,138	568	48	565	225	158	1,564
New York Total	383	9,067	8,171	6,127	902	24,650	1,101	4,156	2,592	2,991	383	11,223
Study Area Total	1206	16,561	15,326	6,254	1,726	41,073	3,707	4,432	3,281	7,613	663	19,696

Table 22 (Continued). **PARTICULATE** EMISSIONS IN THE NEW YORK - NEW JERSEY STUDY AREA, 1966 (tons/year)

	Industrial fuel, excluding power plants						Power plants				Fuel summary					
	Coal		Oil								Coal		Oil			
	Bituminous	Anthracite	Distillate	Residual	Natural gas	Total	Bituminous coal	Residual oil	Natural gas	Total	Bituminous	Anthracite	Distillate	Residual	Natural gas	Total
J-1 Bergen	1,231	-	92	882	41	2,246	3,400	-	68	3,468	5,176	1,384	1,405	1,338	371	9,674
J-2 Essex	219	1	227	517	44	1,008	800	219	17	1,036	1,924	1,511	1,935	1,872	263	7,505
J-3 Hudson	997	5,430	180	626	82	7,315	2,720	527	-	3,247	4,089	6,412	1,217	2,106	192	14,016
J-4 Middlesex	2,784	623	131	2,061	69	5,668	6,065	738	53	6,856	9,250	1,405	903	3,444	234	15,236
J-5 Monmouth	69	-	50	38	24	181	-	-	-	-	334	625	747	138	120	1,964
J-6 Morris	436	528	52	393	17	1,426	-	-	-	-	646	1,018	549	660	81	2,954
J-7 Passaic	1,285	953	71	394	21	2,724	-	-	-	-	1,557	1,641	705	746	127	4,776
J-8 Somerset	342	365	31	193	16	947	-	-	-	-	465	801	304	352	57	1,979
J-9 Union	471	70	165	1,096	134	1,936	-	1,028	-	1,028	807	943	1,078	2,805	245	5,878
New Jersey Total	7,834	7,970	999	6,200	448	23,451	12,985	2,512	138	15,635	24,248	15,740	8,843	13,461	1,690	63,982
Y-1 Bronx	500	22	36	105	12	675		606	42	648	786	2,857	1,055	2,404	157	7,259
Y-2 Brooklyn	526	-	140	706	39	1,411	1,612	1,064	5	2,681	2,315	3,771	3,664	4,266	403	14,419
Y-3 Staten Is.	25	-	34	93	5	157	916	32	-	948	965	644	278	258	65	2,210
Y-4 Manhattan	500	-	53	202	32	787	8,742[a]	796	212	9,750	9,531	4,242	337	3,943	363	18,416
Y-5 Queens	375	-	74	502	24	975	3,913	1,875	241	6,029	4,381	1,209	2,992	3,817	529	12,928
New York City Total	1,926	22	337	1,609	112	4,005	15,183[a]	4,373	500	20,056	17,978	12,723	8,326	14,688	1,517	55,232
Y-6 Nassau	845	5	67	82	14	1,013	858	590	76	1,524	1,703	278	1,721	744	249	4,695
Y-7 Rockland	813	6	4	59	8	890	2,696	5	13	2,714	3,717	18	68	76	91	3,970
Y-8 Westchester	4,002	19	72	141	6	4,240	-	113	-	113	4,362	303	1,128	581	157	6,531
Outer New York Total	5,660	30	143	282	28	6,143	3,554	708	89	4,351	9,782	599	2,917	1,401	497	15,196
New York Total	7,586	52	480	1,890	140	10,148	18,737[a]	5,081	589	24,407	27,760	13,322	11,243	16,089	2,014	70,428
Study Area Total	15,420	8,022	1,479	8,090	588	33,599	31,722[a]	7,593	727	40,042	52,008	29,062	20,086	29,550	3,704	134,410

[a] Includes 47t/yr from anthracite.

Table 22 (Continued). PARTICULATE EMISSIONS IN THE NEW YORK - NEW JERSEY STUDY AREA, 1966 (tons/year)

	Process	Refuse disposal	Motor vehicle			Aircraft & shipping	Total non-fuel	Total emissions	Estimated particle size distribution - weight percent		
			Gasoline	Diesel	Total				$D>44\mu$	$44\mu>D>5\mu$	$D>5\mu$
J-1 Bergen	1,160	664	1,980	982	2,962	-	4,786	14,460	13.9	19.5	66.6
J-2 Essex	996	983	1,862	788	2,650	108	4,737	12,242	14.0	25.6	60.4
J-3 Hudson	2,548	826	924	437	1,361	-	4,735	18,751	29.5	22.5	48.0
J-4 Middlesex	5,707	408	928	1,059	1,987	-	8,102	23,338	14.4	17.6	68.0
J-5 Monmouth	332	352	788	866	1,654	-	2,338	4,302	13.6	26.3	60.1
J-6 Morris	110	245	661	648	1,309	-	1,664	4,618	23.3	29.4	47.3
J-7 Passaic	381	426	785	596	1,381	-	2,188	6,964	31.1	28.3	40.6
J-8 Somerset	1,264	137	261	464	725	-	2,126	4,105	21.9	24.4	53.7
J-9 Union	2,055	1,371	1,186	620	1,806	72	5,304	11,182	13.8	25.4	60.8
New Jersey Total	14,553	5,412	9,375	6,460	15,835	180	35,980	99,962	18.9	22.5	58.6
Y-1 Bronx	35	4,055	1,077	490	1,567	-	5,657	12,916	23.9	31.2	44.9
Y-2 Brooklyn	255	8,868	1,656	753	2,409	-	11,532	25,951	20.7	32.8	46.5
Y-3 Staten Island	360	221	237	141	378	-	959	3,169	11.3	17.1	71.6
Y-4 Manhattan	230	10,330	1,873	744	2,617	-	13,177	31,593	19.6	24.0	56.4
Y-5 Queens	347	3,355	3,137	1,533	4,670	719	9,091	21,654	9.6	22.5	67.9
New York City Total	1,227	26,829	7,980	3,661	11,641	719	40,416	95,648	17.9	26.8	55.3
Y-6 Nassau	189	5,165	2,999	581	3,580	-	8,934	13,629	20.4	27.7	51.9
Y-7 Rockland	3,248	305	417	77	494	-	4,047	8,017	12.6	10.6	76.8
Y-8 Westchester	697	3,543	1,859	352	2,211	-	6,451	12,982	35.6	29.8	34.6
Outer New York Total	4,134	9,013	5,275	1,010	6,285	-	19,432	34,628	24.3	24.5	51.2
New York Total	5,361	35,842	13,255	4,671	17,926	719	59,848	130,276	19.6	26.2	54.2
Harbor Areas		480				585	1,065	1,065			
Study Area Total	19,914	41,734	22,630	11,131	33,761	1,484	96,893	231,303	19.3	24.6	56.1

Table 23. CONTRIBUTIONS OF SOURCE CATEGORIES TO PARTICULATE EMISSIONS IN MAJOR SUBDIVISIONS OF STUDY AREA, 1966

Source category	Particulate contributed, % of total			
	New Jersey	New York City	Outer New York counties	Study area
Non-fuel				
Industrial processes	14.5	1.3	11.9	8.6
Municipal incineration	0.9	12.6	18.8	8.7
On-site incineration	3.9	15.4	6.1	8.7
Open burning	0.7	--	1.2	0.6[a]
Motor vehicles	15.8	12.2	18.2	14.7
Aircraft and shipping	0.2	0.8	--	0.6[b]
Non-fuel subtotal	36.0	42.3	56.2	41.9
Combustion fuels				
Industrial	23.5	4.2	17.7	14.5
Power plants	15.6	21.0	12.6	17.3
Residential	16.4	22.5	9.0	17.8
Govt. and commercial	8.5	10.0	4.5	8.5
Fuel subtotal	64.0	57.7	43.8	58.1
Total particulate, tons/year	99,962	95,648	34,628	231,303[b]

[a] Includes open burning on barges in harbor areas.
[b] Includes shipping emissions in harbor area.

Table 24. CONTRIBUTIONS OF COMBUSTION FUELS TO PARTICULATE EMISSIONS IN MAJOR SUBDIVISIONS OF STUDY AREA, 1966

Fuel	Fraction particulate contributed, % of total			
	New Jersey	New York City	Outer New York counties	Study area
Anthracite coal	15.7	13.3	1.7	12.6
Bituminous coal	24.3	18.8	27.8	22.5
Distillate oil	8.8	8.7	8.5	8.7
Residual oil	13.5	15.4	4.1	12.8
Natural gas	1.7	1.5	1.4	1.5
Combustion fuel Particulate (tons/year)	63,982	55,232	15,196	134,410

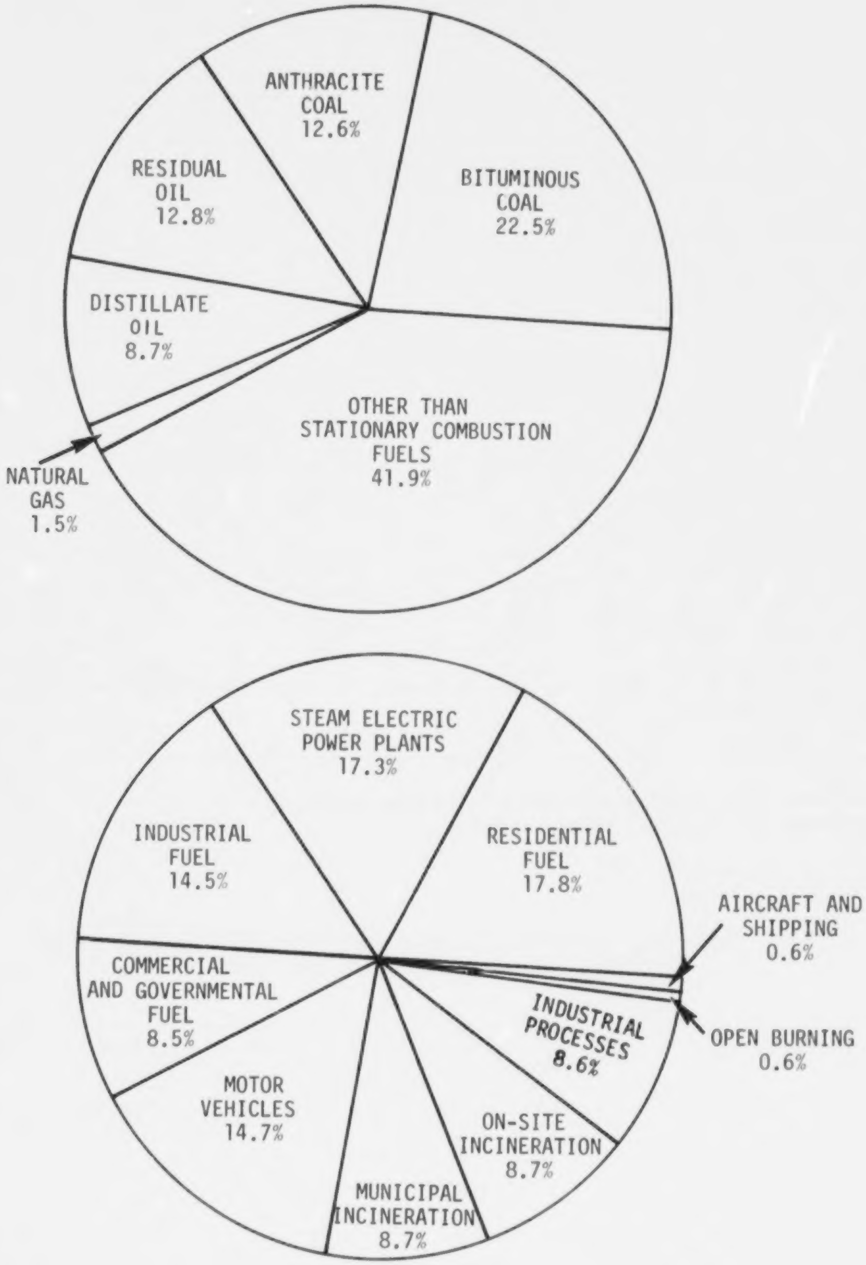

Figure 6. Particulate emitted in total study area by various stationary-combustion fuels (top) and by various sources (bottom).

Combustion of Fuel at Stationary Sources

The particulate inventory for combustion fuels reflects fuel quantities, ash contents and control equipment efficiency as applicable. Average ash contents and control equipment efficiencies were used for area-wide fuel sources. For any specific source, the reported fuel ash content was used for emission calculations. There are no large differences in the ash contents of coals burned in different portions of the study area. Ash contents range from 6 to 12 percent with an average of about 10 percent. Values used for efficiency of control equipment at specific sources were based upon the type of equipment reported and nominal performance for such equipment derived from a variety of sources of information, and not solely on values reported by operators and vendors.

The quantities of fuels burned in the study area are listed in Table 25 and emissions by fuel type are listed in Table 22. Annual consumptions are: 10.5 million tons of bituminous coal, 1.6 million tons of anthracite coal, 3.6 billion gallons of distillate oil, 5.6 billion gallons of residual oil, and 419 billion cubic feet of natural gas.

The percentage of heat supplied by each fuel is by no means proportional to its particulate emissions. Burning of anthracite and bituminous coal collectively provide only 15 percent of the heat, but contributes 60 percent of the combustion fuel particulate total. Residual and distillate oil combustion produces 63 percent of the heat but only 37 percent of the fuel particulate in the area. Natural gas, the cleanest fuel, provides the remaining 22 percent of the heat requirement, but is responsible for only 3 percent of the fuel particulate (Table 26).

The combustion of fuels at steam-electric power plants is a large source of particulate in the study area. Table 27 shows the relative quantities of fuel burned for power generation. Power plants contribute 17 percent, or 40,000 tons, of the total particulate in the area;32,000 tons of these emissions is from coal combustion. At the New Jersey power plants in the study area 73 tons of particulate is emitted per 10^{12} Btu input; in the outer New York counties 78 tons of particulate is emitted per 10^{12} Btu input; and in New York City 55 tons of particulate is emitted per 10^{12} Btu input.

Table 25. FUEL BALANCE IN THE NEW YORK - NEW JERSEY STUDY AREA, 1966

Area	Residential fuel use					Industrial fuel-excluding power plants					Power plants		
	Coal, tons		Fuel oil, 1,000 gal.		Nat. gas,	Coal, tons		Fuel oil, 1,000 gal.		Nat. gas,			
	Bituminous	Anthracite	Distillate	Residual	$10^6 ft^3$	Bituminous	Anthracite	Distillate	Residual	$10^6 ft^3$	Bituminous coal, tons	Residual fuel oil, 1000 gal.	Nat. gas, $10^6 ft^3$
J-1 Bergen	8,600	77,925	218,526	2,927	20,570	154,130	--	16,605	148,772	4,288	1,060,000	--	9,065
J-2 Essex	9,100	84,468	269,761	10,660	14,484	8,594	80	41,317	82,895	4,966	107,000	54,390	2,258
J-3 Hudson	6,000	54,131	174,761	3,555	6,747	70,172	77,646	34,549	109,460	9,234[a]	1,240,000	131,124	--
J-4 Middlesex	4,900	44,613	123,871	205	9,370	183,492	121,372	23,661	357,072	19,620[b]	1,361,450	183,432	7,012
J-5 Monmouth	3,900	35,691	116,609	217	8,418	2,752	--	9,113	6,372	2,688	--	--	--
J-6 Morris	3,100	27,958	82,312	105	5,475	45,716	26,700	9,683	72,263	1,911	--	--	--
J-7 Passaic	4,300	38,665	105,306	1,077	8,655	41,906	29,800	12,896	65,881	2,240	--	--	--
J-8 Somerset	1,700	15,466	44,781	49	3,590	78,661	107,000	5,801	31,881	1,876	--	--	--
J-9 Union	5,404	49,372	153,529	1,965	9,483	39,572	2,010	29,602	188,106	10,093[c]	--	255,570	--
New Jersey Total	47,004	428,289	1,289,456	20,760	86,792	624,995	364,608	183,227	1,062,702	56,916	3,768,450	624,516	18,335
Y-1 Bronx	6,343	120,507	132,056	215,629	7,896	20,000	900	6,427	17,425	1,230	--	150,493	5,607
Y-2 Brooklyn	3,847	148,300	482,305	233,111	31,012	21,040	--	25,246	116,713	4,150	291,399	264,355	751
Y-3 Staten Is.	365	6,554	28,525	14,738	5,168	1,000	--	6,185	15,372	506	748,070[d]	7,959	--
Y-4 Manhattan	9,221	175,422	18,288	398,552	5,064	20,000	--	9,597	33,376	3,346	1,811,528	197,893	28,426
Y-5 Queens	2,170	37,556	412,912	120,018	21,367	15,000	--	13,341	83,057	2,515	2,073,488	428,944	31,983
New York City Total	21,946	488,339	1,074,086	982,048	70,507	77,040	900	60,796	265,943	11,747	4,924,485	1,049,644	66,767
Y-6 Nassau	--	13,491	254,525	--	11,116	26,553	211	12,461	12,804	1,347	283,000	147,000	10,200
Y-7 Rockland	--	680	7,927	--	6,153	57,100	235	806	9,818	629	368,976	1,446	1,729
Y-8 Westchester	--	15,594	135,561	30,737	6,177	120,279	745	12,904	23,316	667[e]	--	25,529	--
Outer New York Total	--	29,765	398,013	30,737	23,446	203,932	1,191	26,171	45,938	2,643	651,976	173,975	11,929
New York Total	21,946	518,104	1,472,099	1,012,785	93,953	280,972	2,091	86,967	311,881	14,390	5,576,461	1,223,619	78,696
Study Area Total	68,950	946,393	2,761,555	1,033,545	180,745	905,967	366,699	270,194	1,374,583	71,306	9,344,911	11,848,135	97,031

[a] Includes 5460 x 10^6 cu. ft. coke oven gas. [b] Includes 9456 x 10^6 cu. ft. refinery gas. [c] Includes 6127 x 10^6 cu. ft. refinery gas.

[d] Includes 3887 tons anthracite coal. [e] Includes 105 x 10^6 cu. ft. propane.

Table 25 (continued). FUEL BALANCE IN THE NEW YORK - NEW JERSEY STUDY AREA, 1966

	Commercial, governmental fuel use					Total fuel use					Motor Vehicles	
	Coal, tons		Fuel oil, 1,000 gal.		Nat. gas, $10^6 ft^3$	Coal, tons		Fuel oil, 1,000 gal.		Nat. gas, $10^6 ft^3$	Gasoline 1,000 gal.	Diesel 1,000 gal.
Area	Bituminous	Anthracite	Distillate	Residual		Bituminous	Anthracite	Distillate	Residual			
J-1 Bergen	22,528	1,204	17,956	72,470	7,053	1,245,258	79,129	253,087	224,169	40,976	359,978	17,908
J-2 Essex	42,614	1,815	38,088	177,130	6,731	167,308	86,363	349,166	325,166	28,439	338,443	14,365
J-3 Hudson	15,265	1,976	12,217	153,950	4,880	1,331,437	133,753	221,527	398,089	20,861	167,968	7,971
J-4 Middlesex	18,052	35	15,258	106,540	2,385	1,567,894	166,020	162,790	647,249	38,387	168,784	19,278
J-5 Monmouth	11,264	--	8,978	16,320	1,673	17,916	35,691	134,700	22,909	12,779	143,278	15,762
J-6 Morris	8,940	50	7,162	43,880	1,284	57,756	54,708	99,157	116,248	8,670	120,159	11,822
J-7 Passaic	11,264	617	8,978	57,110	2,490	57,470	69,082	127,180	124,068	13,385	142,655	10,792
J-8 Somerset	5,306	9,505	4,290	26,280	716	85,667	131,971	54,872	58,210	6,182	47,391	8,455
J-9 Union	13,767	522	11,073	110,520	2,238	58,743	51,904	194,204	556,161	21,814	215,558	11,311
New Jersey Total	149,000	15,724	124,000	764,200	29,450	4,589,449	808,621	1,596,683	2,472,178	191,493	1,704,214	117,664
Y-1 Bronx	10,000	41,508	51,501	64,170	2,937	36,343	162,915	189,984	447,717	17,670	195,813	8,908
Y-2 Brooklyn	6,300	67,202	152,701	179,762	6,658	322,586	215,502	660,252	793,941	42,571	301,059	13,692
Y-3 Staten Is.	1,000	30,248	15,417	7,240	1,110	750,435	36,802	50,127	45,309	6,784	43,048	2,558
Y-4 Manhattan	10,000	64,313	32,823	88,184	7,517	1,846,862	243,622	60,708	718,005	44,353	340,510	13,529
Y-5 Queens	3,000	31,525	112,734	117,980	5,518	2,093,658	69,081	538,987	749,999	61,383	570,432	27,872
New York City Total	30,300	234,796	365,176	457,336	23,740	5,049,884	727,922	1,500,058	2,754,971	172,761	1,450,862	66,559
Y-6 Nassau	--	2,110	43,406	11,968	5,628	309,553	15,812	310,392	171,772	28,291	545,200	10,562
Y-7 Rockland	17,155	155	3,517	1,965	1,188	443,231	1,070	12,250	13,229	9,699	75,818	1,393
Y-8 Westchester	21,269	617	60,207	23,399	9,838	141,548	16,956	208,672	102,981	16,682	338,030	6,398
Outer New York Total	38,424	2,882	107,130	37,332	16,654	894,332	33,838	531,314	287,982	54,672	959,048	18,353
New York Total	68,724	237,678	472,306	494,668	40,394	5,944,216	761,760	2,031,372	3,042,953	227,433	2,409,910	84,912
Harbor Areas	--	--	--	--	--	--	--	--	80,372	--	--	6,783
Study Area Total	217,724	253,402	596,306	1,258,868	69,844	10,533,665	1,570,381	3,628,055	5,595,503	418,926	4,114,124	209,359

Table 26. RELATIVE QUANTITIES OF PRINCIPAL FUELS USED IN MAJOR SUBDIVISIONS OF STUDY AREA, 1966

Fuel[a]	Heat supplied, % of total			
	New Jersey	New York City	Outer New York counties	Study area
Residual oil	39	43	22	39
Bituminous coal	13	13	11	13
Distillate oil	24	22	37	24
Anthracite coal	2	2	0	2
Natural gas	22	20	30	22
Gross heat input, Btu/year	954×10^{12}	972×10^{12}	203×10^{12}	2129×10^{12}

[a] Gross heating values: Residual oil, 152,000 Btu/gal; distillate oil, 142,000 Btu/gal; bituminous and anthracite coal, 26,000,000 Btu/ton; natural gas, 1,100 Btu/scf.

These emission ratios reflect differences in the amounts of coal and other fuels burned, and in the efficiencies of dust collectors installed at the plants. Electrostatic precipitators, the most efficient control devices used in the area's power plants, are operated only during coal burning. Residual oil is used to supply about 45 percent of the fuel requirements at power plants in the study area, but the relative quantities of natural gas and bituminous coal differ markedly. In the outer New York counties, natural gas is used for 23 percent of the power generation; in New York City, 21 percent; and in New Jersey, only 9 percent. New Jersey plants use bituminous coal to supply 46 percent of their needs, as compared to 35 percent for New York City and 30 percent for the outer counties. There was a general increase in residual oil burning at power plants in 1966 over 1965. In New Jersey and the outer New York counties there was a corresponding decrease in natural gas use.

Only three small coal-fired power plant steam generators in the study area

Table 27. RELATIVE QUANTITIES OF PRINCIPAL FUELS USED BY STEAM-ELECTRIC POWER PLANTS IN MAJOR SUBDIVISIONS OF STUDY AREA, 1966

Fuel[a]	Heat supplied, % of total				
	New Jersey	New York City	Outer New York counties	Avg. New York	Study area
Residual oil	45	44	47	44	45
Bituminous coal	46	35	30	35	38
Natural gas	9	21	23	21	17
Gross heat input, Btu/year	213×10^{12}	362×10^{12}	56×10^{12}	418×10^{12}	613×10^{12}

[a] Gross heating values: Residual oil 152,000 Btu/gal; bituminous coal 26,000,000 Btu/ton; and natural gas 1,100 Btu/scf.

are not equipped with dust collection equipment. These units produce less than 10 percent of the power at one of the New Jersey stations. All other coal-fired electric utility plants in the area are equipped with centrifugal collectors, electrostatic precipitators, or combinations of the two. Multiple-cyclone collectors collect about 85 percent of the particulate vented to them. Installed precipitators or combinations of precipitators and centrifugal collectors are rated at 85 to 99 percent efficiency by the manufacturer. For inventory purposes, many of these efficiencies were estimated to be lower than the manufacturer's ratings to reflect the greater-than-normal particulate discharge when soot is blown, when the equipment is out of adjustment, and when steam generators are operated above rated capacity. Rated control equipment efficiency ranges for power plants in the three major subdivisions of the survey area are as follows: New Jersey, 0-99 percent; New York City, 90-99 percent; and outer counties, 85-98 percent.

Particulates from fuel combustion at sources other than power plants are shown in Tables 22, 23, and 24. Total emissions from all residential fuel combustion are 41,000 tons per year (18 percent of area-wide total from all sources); from commercial and governmental fuel combustion, 19,700 tons (8.5 percent); and from industrial fuel combustion, 33,600 tons (15 percent).

When analyzed separately for New Jersey, New York City, and the outlying New York counties, the above totals reflect the concentrations of large residential and commercial buildings in New York City, the suburban character of the outer New York counties, and the greater industrialization in New Jersey. Tables 23, 24, and 25 show these relative differences of fuel usage by source category for the three major areas.

Since coal burning is responsible for 35 percent of the particulate emissions in the study area, the effect of various control techniques is pertinent. Table 28 shows by source categories the amounts of bituminous and anthracite coal burned, collector efficiency ranges, average collector efficiencies, and quantities of particulates emitted. Control equipment efficiency can vary from high efficiency (99 percent rating) electrostatic precipitators at power plants to simple mechanical

Table 28. COAL BURNING OPERATIONS IN NEW YORK - NEW JERSEY STUDY AREA, 1966

Operation	Quantity burned, tons/year	Collector efficiency, %		Particulate emissions	
		Range	Average	tons/year	lb/ton coal
Power plants					
Anthracite	3,887	88	88.0	47	24.2
Bituminous	9,341,024	0-98	94.9	31,675	6.8
Industrial					
Anthracite	366,699	0-93	12.5	8,022	43.8
Bituminous	905,967	0-95	31.9	15,420	34.0
Comm. & Govt.					
Anthracite	253,402	0	0	4,432	35.0
Bituminous	217,724	0-80.5	2.7	3,707	34.1
Residential					
Anthracite	946,393	0	0	16,561	35.0
Bituminous	68,950	0	0	1,206	35.0
Subtotal, ant.	1,570,381	0-93	4.9	29,062	37.0
Subtotal, bit.	10,533,665	0-98	92.0	52,008	9.9
	12,104,046	0-98	88.1	81,070	13.4

collectors and settling chambers at small industrial and commercial establishments. A few scrubbers are operated, but no full-scale baghouses are in use for combustion sources. At most residential, commercial, governmental, and small industrial sources, coal is burned without any control equipment. Table 28 shows that as a result of dust collection practices, emissions from controlled power plants average 7 pounds per ton of coal burned whereas the averages for small coal-burning sources range from 34 to 44 pounds of particulate per ton of coal burned.

The relative effects of the controlled and uncontrolled coal burning sources are shown in Table 29. Potential emissions from power plants are decreased 95 percent because of control techniques, but emissions from other bituminous and anthracite coal combustion sources are decreased only 26 and 5 percent, respectively.

Particulate emissions from oil and natural gas combustion are not controlled to any measurable degree. At a few coal-fired power plants centrifugal collectors provide a modicum of collection during oil firing.

Industrial Process Emissions

Industrial process sources in the study area produce 19,900 tons of particulate per year. These contaminant releases represent 8.6 percent of the area total and 15 percent of the annual total in the New Jersey portion where most of the process sources are located. Major types of process sources for particulates are listed in Table 30. These source types emit about 50 percent of the total process emissions, with non-ferrous melting operations being responsible for 16 percent and gray iron foundries and catalyst regenerators each contributing 8 percent.

Table 30 also shows the effect of control facilities at these types of industrial sources. Efficiencies of control equipment at the process sources range from zero (no control) to 99.99 percent for petroleum catalyst regenerators, where control is important for economic as well as for air pollution control purposes. Neglecting catalyst regenerators, the use of control equipment reduces the emissions from these selected sources from 155,000 to 8,000 tons per year, a decrease of 95 percent.

Table 29. CONTROL OF PARTICULATE EMISSIONS FOR MAJOR SOURCE CATEGORIES WITH SIZE DISTRIBUTION IN NEW YORK - NEW JERSEY STUDY AREA, 1966

Source	Collection efficiencies,%		Emissions, tons/year		Particle size distributions,% by wt		
	Range	Average	Potential	Actual	>44μ	<44>5μ	<5μ
Natural gas burning	--	0	3,704	3,704	--	--	100
Distillate oil burning	--	0	20,086	20,086	--	50	50
Residual oil burning	0-25[a]	0	29,550	29,550	--	38	62
Bituminous coal-power plant	0-98	94.9	620,758	31,675	--	--	100
Bituminous coal-other	0-95	26.5	27,665	20,333	67	27	6
Anthracite coal	0-93	4.9	30,552	29,062	45	18	37
Industrial processes	0-99.99	c	c	19,914	5	10	85
Municipal incineration	b			19,498	40	45	15
On-site incineration	b			20,702	40	45	15
Open burning	b			1,534	40	45	15
Motor vehicles							
Gasoline	--	0	22,630	22,630	--	--	100
Diesel	--	0	11,131	11,131	--	37.5	62.5
Motor vehicle subtotal	--	0	33,761	33,761	--	12	88
Ships & aircraft	--	0	1,484	1,484	--	--	100
Total	0-99.99	c	c	231,303	19.3	24.6	56.1

[a] Some centrifugal collectors used at coal- or oil-fired power plant.
[b] Reliable data not available regarding the few control devices in use.
[c] Insufficient data for estimate.

Table 30. EMISSIONS OF PARTICULATE AND COLLECTION EFFICIENCIES AT SELECTED INDUSTRIAL PROCESSES IN NEW YORK - NEW JERSEY STUDY AREA, 1966

Source	Particulate type	Collector efficiency, %		Emissions, tons/year		Particle size distribution, % by wt.		
		Range	Average	Potential	Actual	D >44μ	44μ>D>5μ	D <5μ
Petroleum catalyst regen.	Dust	91-99.99	99.95	3,344,933	1,625	--	20	80
Gray iron cupolas	Dust and smoke	0-85	21.0	1,892	1,495	42	36	22
Asphalt batch plants	Dust	80.0-99.2				--	17	83
Sulfuric acid mfg.	Acid mist	0-99	93.1	6,912	477	--	5	95
Non-ferrous melting	Dust and fumes	0-99.6	88.6	27,811	3,171	--	10	90
Gypsum processing	Dust	97.0-99.5	98.7	104,533	1,386	a		
Asphalt blowing and saturation	Oil mist	0-90	53.9	1,621	748	a		

[a] Insufficient data available.

Refuse Incineration And Open Burning

The amounts of refuse disposed of by various techniques are shown in Tables 31 and 32 and in Figure 7. Landfilling, a principal disposal method in New Jersey, produces negligible particulates. On the other hand, incineration and open burning of refuse account for 18 percent of the total area-wide particulate emissions. Most of this total is attributable to on-site and municipal incineration, each contributing 8.7 percent of the total particulate. The on-site problem mainly is related to residential flue-fed incinerators in New York City.

As can be seen from Table 32, 87 percent of the refuse in the New Jersey portion of the survey area is disposed of by landfill, and in the outer New York counties and New York City, the fractions are 53 and 50 percent, respectively. Municipal incineration is a common disposal method in the New York portion of the study area. New York City disposes of 34 percent of its refuse in municipal incinerators, and the outer counties dispose of 37 percent by this method. In New Jersey municipal incineration accounts for disposal of only 4.3 percent of the refuse. Municipal incineration, a major source of particulate in the outer counties of New York, contributes 19 percent of the total emissions.

Many on-site incinerators are of flue-fed design and are used in apartment houses. Flue-fed incinerators are heavily concentrated in New York City. Table 32 shows that in New York City 17 percent of the refuse is burned in on-site incinerators and that in New Jersey and the outer counties only 7 and 9 percent, respectively, of the refuse is disposed of in this manner. On-site incineration accounts for 15 percent of the particulate generated in New York City.

The amount of reported refuse disposed of by backyard burning or open burning is small in comparison to other disposal methods. Open burning includes refuse disposal on barges in the harbor area. This method of disposal (1 percent of the refuse) accounts for less than 1 percent of the particulate in the total study area. Much refuse burned in barges is in the form of driftwood and rotted pilings.

Table 31. REFUSE INCINERATION AND OPEN BURNING IN NEW YORK - NEW JERSEY STUDY AREA, 1966 (tons/year)

Area	Municipal incineration		On-site incineration		Open Burning		Totals	
	Refuse	Particulate	Refuse	Particulate	Refuse	Particulate	Refuse	Particulate
J-1 Bergen	27,273	240	27,400	315	10,946	109	65,619	664
J-2 Essex	--	--	12,295	935	4,750	48	77,045	983
J-3 Hudson	118,359	436	29,007	378	1,196	12	148,562	826
J-4 Middlesex	14,000	105	17,690	193	11,011	110	42,701	408
J-5 Monmouth	14,546	108	11,915	135	10,852	109	37,313	352
J-6 Morris	--	--	11,961	138	10,739	107	22,700	245
J-7 Passaic	--	--	30,581	371	5,518	55	36,099	426
J-8 Somerset	--	--	4,113	85	5,182	52	9,295	137
J-9 Union	--	--	68,297	1,315	5,555	56	73,852	1,317
New Jersey Total	174,178	889	273,259	3,865	65,749	658	513,186	5,412
Y-1 Bronx	150,897	821	248,600	3,234	--	--	399,497	4,055
Y-2 Brooklyn	1,058,580	5,371	267,800	3,497	--	--	1,326,380	8,868
Y-3 Staten Is.	--	--	17,000	221	--	--	17,000	221
Y-4 Manhattan	727,407	4,352	458,800	5,978	--	--	1,186,207	10,330
Y-5 Queens	295,116	1,554	137,800	1,801	--	--	432,916	3,355
New York City Total	2,232,000	12,098	1,130,000	14,731	--	--	3,362,000	26,829
Y-6 Nassau	413,200	4,132	80,628	902	13,087	131	506,915	5,165
Y-7 Rockland	28,851	144	8,473	109	5,215	52	42,539	305
Y-8 Westchester	307,567	2,235	85,302	1,095	21,275	213	414,144	3,543
Outer New York Total	749,618	6,511	174,403	2,106	39,577	396	963,598	9,013
New York total	2.981,618	18,609	1,304,403	16,837	39,577	396	4,325,598	35,842
Harbor areas					48,000	480	48,000	480
Study area total	3,155,796	19,498	1,577,662	20,702	153,326	1,534	4,886,784	41,734

Table 32. COMBUSTIBLE REFUSE DISPOSAL METHODS IN THE STUDY AREA, 1966

Disposal method	Fraction refuse disposed, % of total			
	New Jersey	New York City	Outer New York counties	Study area
Incineration				
On-site	6.7	17.0	8.5	12.3
Municipal	4.3	33.5	36.6	24.6
Incineration Sub total	11.0	50.5	45.1	36.9
Open burning	1.6	0	1.9	0.9
Total combustion	12.6	50.5	47.0	37.8
Landfill[a]	87.4	49.5	53.0	62.2
Total refuse (tons/year)[b]	4,083,000	6,665,000	2,048,000	12,796,000

[a] Assuming all refuse not burned is disposed of in landfill.
[b] Based on refuse generation of 4.5 lb/capita-day.

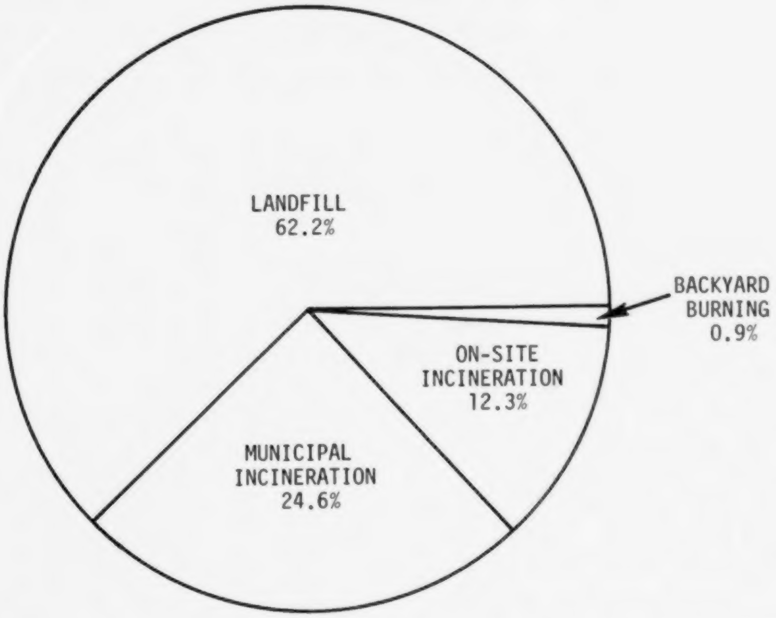

Figure 7. Refuse disposal by various methods in total study area.

Mobile Sources

The mobile source category includes motor vehicles (gasoline and diesel powered), aircraft, and ships. The total fuel usage by motor vehicles is shown in Table 25. Boiler- and diesel-fuel usage were assumed to constitute the only emission sources on ships. Jet aircraft are responsible for most of the aircraft particulate.

Motor vehicles emit 33,800 tons per year of particulate, or 15 percent of the area total. Aircraft and ship operations contribute a comparatively smaller amount, 1,500 tons per year, or 0.6 percent. Emissions from motor vehicles surprisingly rank third in emission totals behind steam-electric power plants and residential fuel usage (Table 23).

Point Sources

Any individual site in the survey area from which 100 or more tons of particulate was discharged in 1966 is considered a point source. The current inventory shows 137 such sources in the 17 counties. These sources include 26 steam-electric power plants, 73 industrial sites (fuel, process, and incineration combined), 31 municipal incinerators, and 7 miscellaneous coal-burning operations. At several of the industrial plants, coal burning is the overriding source of particulate emissions.

These 137 point sources contribute 43 percent, or 98,500 tons per year, of the particulate emissions in the area. Industrial point sources generate 38,300 tons of particulate per year, or 17 percent of the area total. Power plant point sources contribute 17 percent of the total particualte (39,000 tons), and the 31 point source municipal incinerators emit 19,000 tons of particulate, or 8.2 percent of the total. Point sources are located on the map in Figure 8. Larger sources emitting more than 1,000 tons of particulate per year are coded by source type in Figure 9.

Variation in Particulate Emissions Due To Space Heating

As illustrated by Table 33, increased fuel burning during space-heating days results in greater particulate emissions than occur on days when space-heating is not required. On a maximum space-heating day particulate emissions aggregate 1,126 tons, more than twice that of a summer day when no space-heating is required.

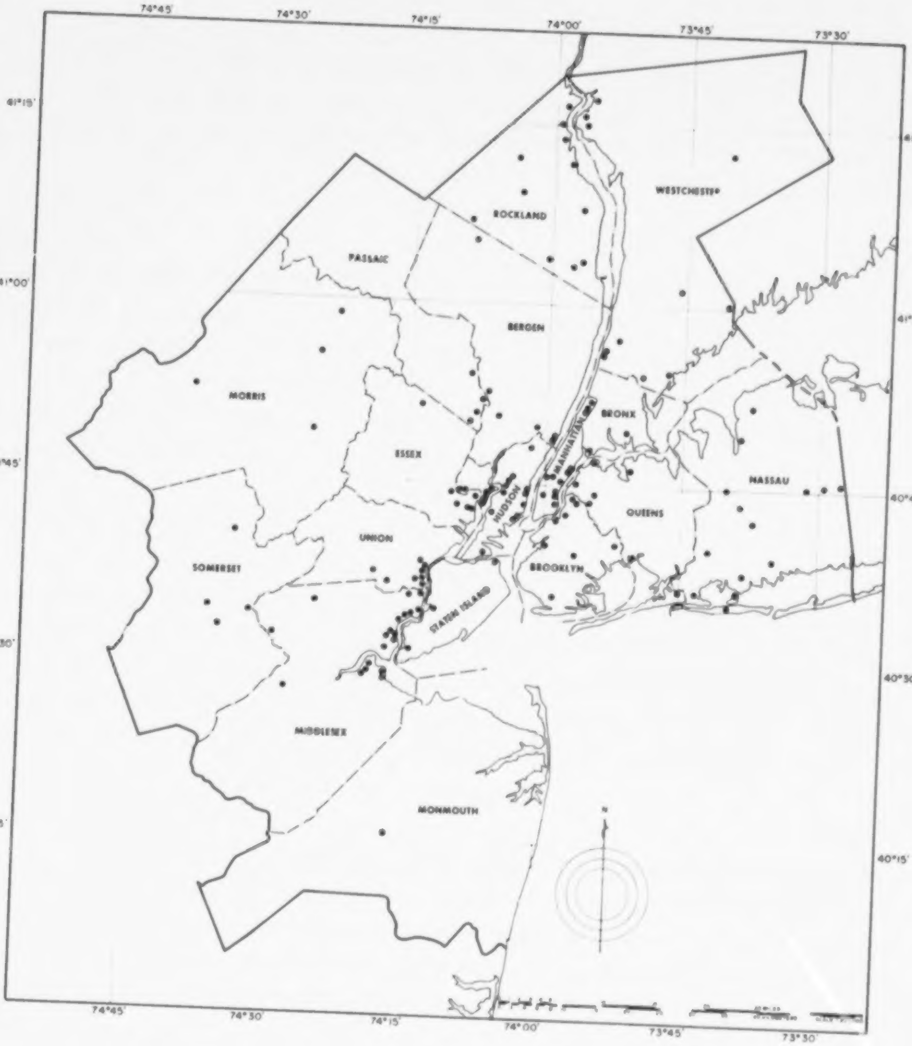
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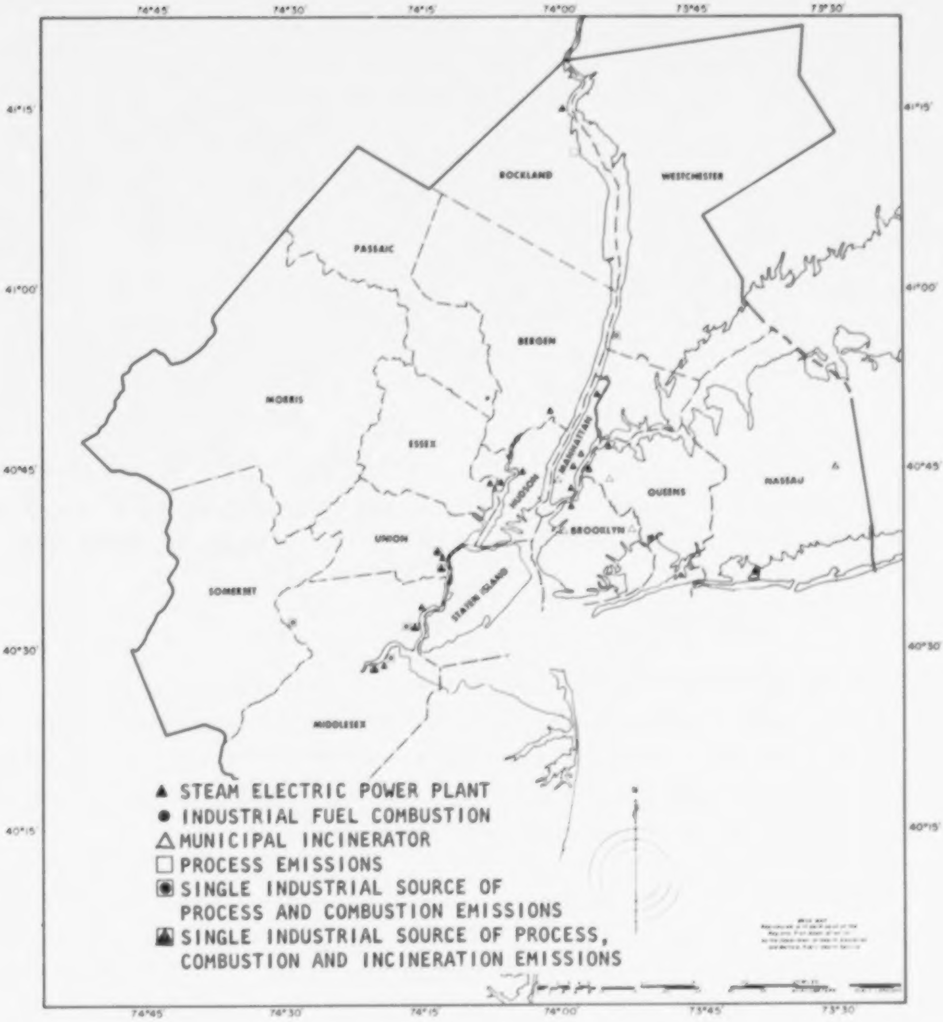
Figure 8. Particulate point sources in study area.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UNION
SOMERSET
STATEN ISLAND
MIDDLESEX
▲ STEAM ELECTRIC POWER PLANT
● INDUSTRIAL FUEL COMBUSTION
△ MUNICIPAL INCINERATOR
☐ PROCESS EMISSIONS
SINGLE INDUSTRIAL SOURCE OF PROCESS AND COMBUSTION EMISSIONS
SINGLE INDUSTRIAL SOURCE OF PROCESS, COMBUSTION AND INCINERATION EMISSIONS

Figure 9. Point sources that emit more than 1000 tons of particulate annually.

Table 33. PARTICULATE EMISSIONS FOR MINIMUM, AVERAGE, AND MAXIMUM SPACE-HEATING DAYS BY SOURCE TYPE (tons/day)

Sources	Minimum	Average	Maximum
Refuse	159.8	159.8	159.8
Mobile	96.6	96.6	96.6
Process	66.4	66.4	66.4
Industrial fuel	78.1	111.5	158.5
Power plants	109.7	109.7	109.7
Residential fuel	13.5	162.0	348.5
Comm. and govt. fuel	neg	81.7	186.3
Total	524.1	787.7	1125.8

Over 80 percent of the 231,000-ton annual particulate total is contributed by sources operated at approximately the same rate throughout the year, i.e. power plants, industrial processes and coal burning, refuse incineration, motor vehicles, shipping, and aircraft.

In Table 34 daily particulate totals are listed by county for minimum, average, and maximum space-heating days. Sources in the 314-square-mile area of New York City are seen to discharge about the same tonnage as those in the 2,266 square miles of the nine New Jersey counties and considerably more than those in the 913 square miles of the outer New York counties.

Particulate emission densities in terms of tons per day per square mile are listed in Table 35. The four heavily populated boroughs of New York City and Hudson County in New Jersey have the greatest emission densities.

Comparative values for the relatively industrialized counties of Middlesex and Union are appreciably lower than those for the heavily populated areas. These figures tend to reflect the greater quantities of refuse incinerated and the heavier concentration of power plants in New York City. The relatively high densities of Hudson County are traceable to a few large coal-burning operations including power

Table 34. PARTICULATE EMISSIONS FOR MINIMUM, AVERAGE, AND MAXIMUM SPACE-HEATING DAYS BY COUNTY (tons/day)

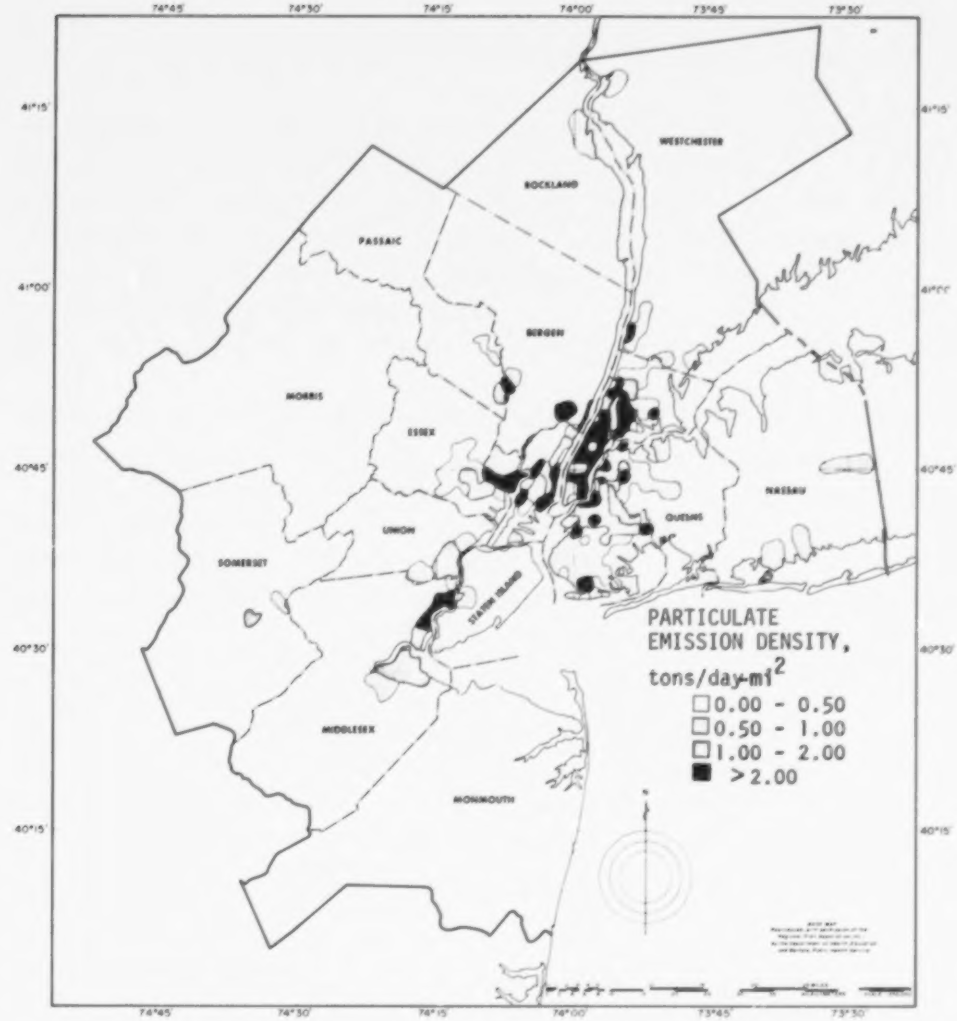
Area	Minimum	Average	Maximum
Bergen	30.6	48.1	70.4
Essex	20.6	43.0	71.7
Hudson	43.5	64.1	90.6
Middlesex	59.8	75.8	96.5
Monmouth	7.8	14.9	24.0
Morris	8.8	16.1	25.5
Passaic	14.0	24.6	38.3
Somerset	9.3	14.3	20.6
Union	25.4	38.4	55.2
New Jersey total	219.8	339.3	492.8
Bronx	24.5	48.1	78.5
Brooklyn	54.0	95.7	149.0
Staten Island	6.1	10.8	16.7
Manhattan	80.6	107.5	141.9
Queens	39.0	62.8	93.3
New York City total	204.2	324.9	479.4
Nassau	37.2	46.1	57.5
Rockland	25.8	28.1	31.0
Westchester	33.6	45.8	61.6
Outer New York total	96.6	120.0	150.1
Harbor areas	3.5	3.5	3.5
Study area total	524.1	787.7	1125.8

Table 35. PARTICULATE EMISSION DENSITY FOR MINIMUM, AVERAGE, AND MAXIMUM SPACE-HEATING DAYS BY COUNTY (tons/day - mi^2)

County	Minimum day	Average day	Maximum day
New Jersey			
Bergen	0.13	0.21	0.30
Essex	0.16	0.34	0.56
Hudson	0.97	1.43	2.01
Middlesex	0.19	0.24	0.31
Monmouth	0.02	0.03	0.05
Morris	0.02	0.03	0.05
Passaic	0.07	0.13	0.20
Somerset	0.03	0.04	0.07
Union	0.25	0.37	0.54
New York			
Bronx	0.57	1.12	1.82
Brooklyn	0.70	1.24	1.95
Staten Island	0.10	0.18	0.28
Manhattan	3.66	4.89	6.45
Queens	0.34	0.55	0.82
Nassau	0.12	0.15	0.19
Rockland	0.15	0.16	0.17
Westchester	0.08	0.11	0.14

generation and refuse incineration, and to the small land area (45 square miles) of the County. By far the greatest emission densities are found in Manhattan, where values range from 3.7 tons per square mile on a minimum heating day to 6.4 tons per square mile on a maximum heating day. Manhattan emission densities are more than three times greater than those of Hudson County, the next most contaminated area.

In Appendix C, emission densities are listed for each of the zones in the study area for an average day. These emission densities are plotted for areas of equal concentration in Figure 10. Since zones are considerably smaller than counties, these values show sharp differences in emission levels where major point sources are concerned. The greatest zone density was calculated for a small (0.3 square mile) zone (Y-8-39) in Westchester County, in which two large coal-burning industrial sites are located. Six of the square-mile zones in New York City have emission densities exceeding 10 tons per average day. In many rural zones densities are less than 0.10 ton per square mile per day.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PASSAIC
BERGEN
MORRIS
ESSEX
NASSAU
QUEENS
UNION
SOMERSET
STATEN ISLAND
MIDDLESEX
MONMOUTH
PARTICULATE EMISSION DENSITY, tons/day-mi²
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☐ 0.50 - 1.00
☐ 1.00 - 2.00
■ >2.00

Figure 10. Particulate emission density by zone in study area.

Particle Size Distribution

For each county, estimates were made of the fractions of particulate emissions in three significant particle-size ranges, i.e. greater than 44 microns, 5 to 44 microns, and less than 5 microns (Table 22). Settleable dust is considered to be greater than 44 microns in diameter. Smaller particles tend to remain airborne and make up the principal fraction of what is measured as suspended particulate. Particles smaller than about 5 microns are generally in the size range which can be inspired into the human respiratory system. The less-than-5-micron range includes submicron particles, which contribute most to the reduction of visibility.

In the study area, 19 percent, by weight, of the particulate emissions were estimated to be greater than 44 microns, 25 percent between 5 and 44 microns, and the largest fraction (56 percent) less than 5 microns in diameter. Differences in particle size distribution in the 17 counties are due mainly to the intensity of refuse burning and "other coal burning" (industrial, residential, commercial, and governmental sources). Essentially all of the coarse particles generated in power plant boilers are collected in centrifugal separators and electrostatic precipitators.

There are no significant differences in particle size distribution between overall New York and New Jersey areas; however, there is a marked contrast in sources. About 70 percent of the coarse pollutants generated in New Jersey are due to coal burning. In New York, a comparable quantity of coarse particles is generated by refuse incineration. Richmond County (Staten Island) exhibits the lowest fraction of coarse and the greatest fraction of fines (71 percent) because of the sparsity of incineration and uncontrolled coal burning.

METEOROLOGICAL REPRESENTATIVENESS

The atmosphere is the medium which transports and disperses air contaminants. Meteorological information observed during January through May 1967, when most of the air-quality data were collected, were analyzed and compared to meteorological data collected over the 10-year period January through May 1951-60 to ascertain if the weather during the sampling period was representative of the weather normally experienced in the New York-New Jersey Metropolitan area during the first five months of the year. The analyses and comparisons allow judgments to be made as to the probable representativeness of the air quality data acquired during this portion of the sampling period.

Weather data collected by the U.S. Weather Bureau at three long-established observation sites in the central portion of the survey area were selected for analysis. The sites were: LaGuardia Field, Central Park Observatory, and Newark Airport.

The area's temperature during the sampling period averaged two degrees below normal. January was definitely warmer than normal, but the other months, especially May, were colder. Precipitation was near normal, but the area was markedly drier than normal in January and wetter in March. There was slightly more daytime cloudiness than normal, but the departure was not significant.

Average wind speed, an important indicator of the capability of the air to disperse pollutants, was very near expected values. Winds averaged 0.5 mph below normal at LaGuardia and Central Park and 0.5 mph above normal at Newark. At all three stations, occurrences of calms and light wind speeds were fewer than normal. However, appreciably fewer than normal incidents of strong winds caused the average wind speed at Central Park and LaGuardia to be below normal. At Newark, which experienced slightly greater than normal average wind speed, stronger winds occurred with usual frequency.

Wind roses (Fig. 11 through 16) provided indications of the frequency that contaminants were transported in various directions. The frequency distributions of wind directions varied from normal distributions from site to site. Central Park experienced more northeasterly and northwesterly and fewer westerly winds than normal; Newark, more northerly, southeasterly and southwesterly and fewer northeasterly winds; and LaGuardia more northerly and southerly and fewer northwesterly and southeasterly winds.

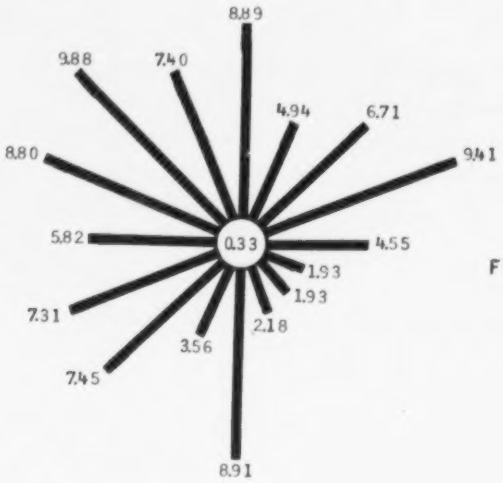


Figure 11. Percentage frequency of surface wind direction from January through May, 1967, at La Guardia Airport.

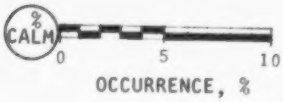
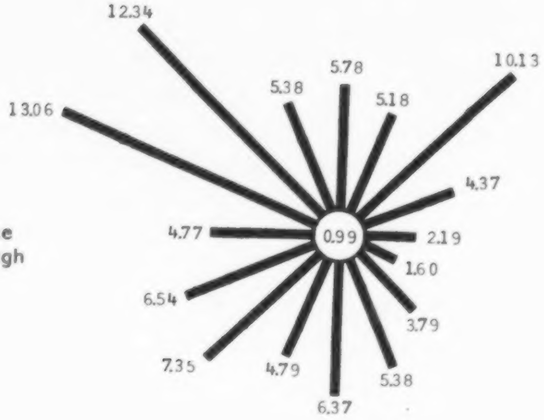


Figure 12. Percentage frequency of surface wind direction from 1951 through 1960 at La Guardia Airport.



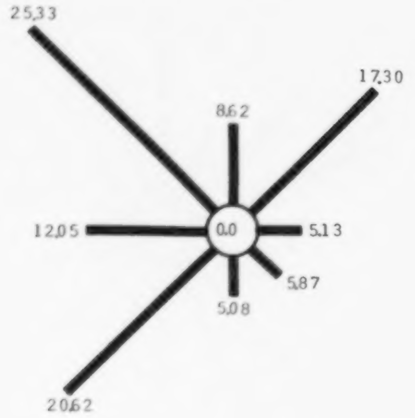
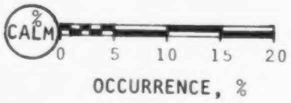


Figure 13. Percentage frequency of surface wind direction from January through May, 1967, at Central Park Station.



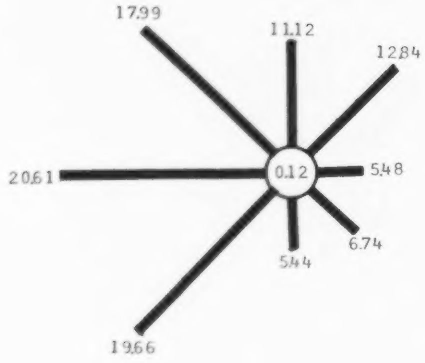
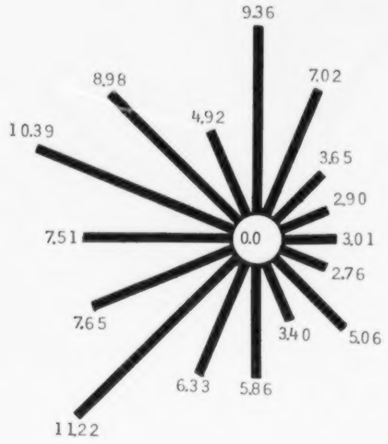
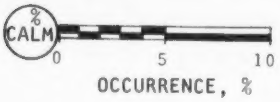


Figure 14. Percentage frequency of surface wind direction from January through May for 1961 through 1965 at Central Park Station.

Figure 15. Percentage frequency of surface wind direction from January through May, 1967, at Newark Airport.





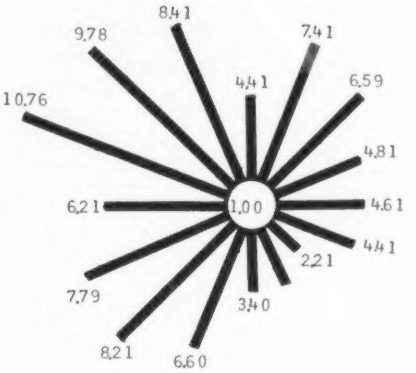
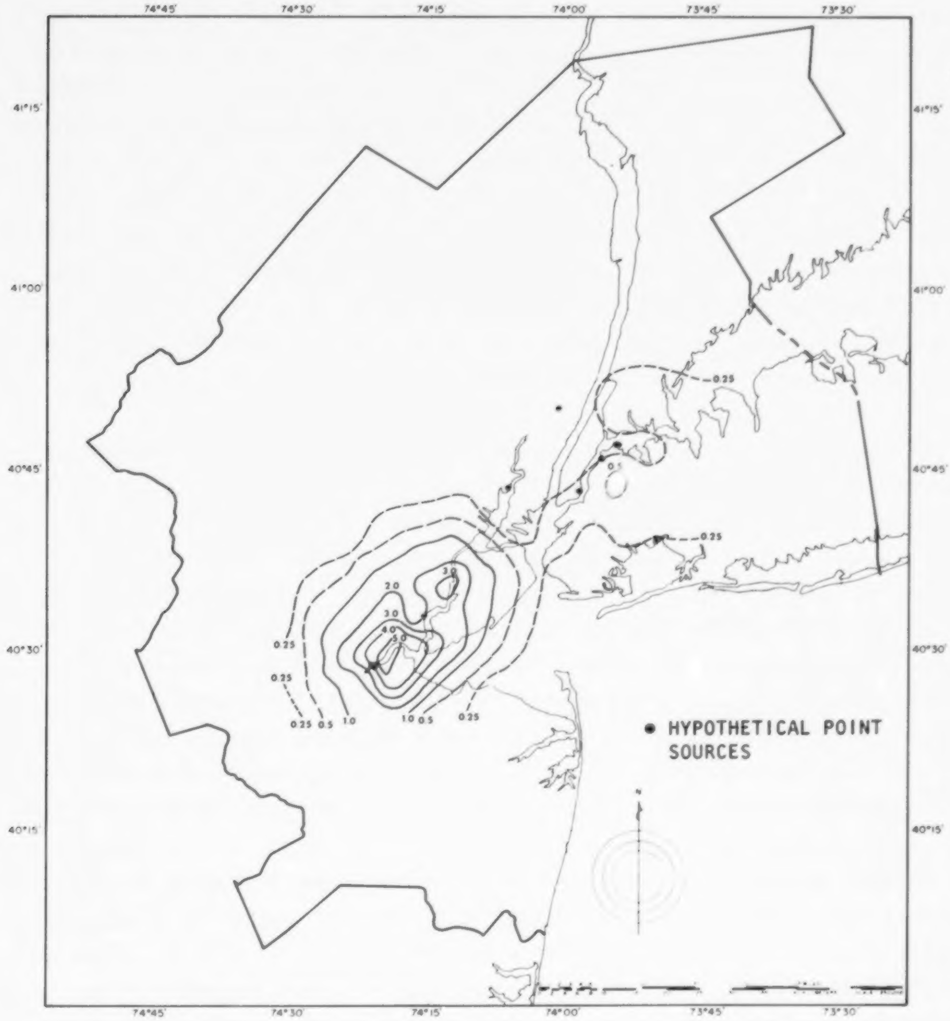


Figure 16. Percentage frequency of surface wind direction from January through May for 1951 through 1960 at Newark Airport.

To ascertain the extent that the variations from normal of the wind speed and direction occurrences during January through May 1967 would cause anomalous distributions of suspended particulates during the period, the theoretical frequency of occurrence of 50 micrograms per cubic meter or more were calculated for 269 uniformly spaced grid points over the area. Two sets of calculations were made. One set used the average wind patterns for January through May for a 10-year period 1951-60. The other set used wind patterns for January through May 1967. All other factors and assumptions used in the two sets of computations were identical. It was assumed that seven hypothetical point-sources existed in the New York - New Jersey area. Each hypothetical source was assumed to emit particulates at a constant rate throughout the year; to have stack dimensions, stack-gas temperatures and stack-gas velocities which were typical of large sources in the vicinity of New York City; and to be located in an area where actual emissions were known to be high. It was assumed that an inversion at 500 meters above the ground limited the vertical dispersion of pollutants; below the inversion the atmosphere always possessed neutral stability. The frequency of observed wind directions and speeds at LaGuardia Field were applied to the two easternmost hypothetical sources; at Central Park were applied to the two centrally located sources; and at Newark Airport to the three westernmost sources.

The theoretical distribution of frequency of occurrence of suspended particulate pollutants based on the 10-year (normal) wind patterns is shown in Figure 17. The theoretical distribution using the 1967 wind patterns is shown in Figure 18. If the two theoretical distributions were precisely identical, it is reasoned that the winds which dispersed pollutants in January through May 1967 were representative of the ten-year average wind condition for these months and, providing emissions do not change, the contamination experienced throughout the area should have been essentially representative of the long-term average. In fact, the theoretical distributions of pollutants as illustrated in Figures 17 and 18 are quite similar. Differences which should be noted occur over Brooklyn, Queens, the southern portion of the Bronx and the southwestern portion of Staten Island. It appears these areas should have experienced slightly greater pollution than normal, apparently as a consequence of more frequent southwesterly winds than normal at Newark and northwesterly and northeasterly winds at Central Park. Near Raritan Bay the 1967 frequency of occurrence was less than the long-term, so contamination during the first five months of 1967 should have been somewhat less than would be expected in the long-term. This circumstance is attributed to fewer northeasterly winds than normal at Newark.

It is concluded that the dispersive capability of the atmosphere was about normal during January through May 1967. However, the variations from the normal wind directions, particularly at Central Park and Newark, should have caused the pattern of contamination to be shifted somewhat to the east. The eastern portions of the metropolitan area should have experienced slightly more contamination than normal, the western and northern portions about average, and the extreme southern portion slightly less than average contamination.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41°00'
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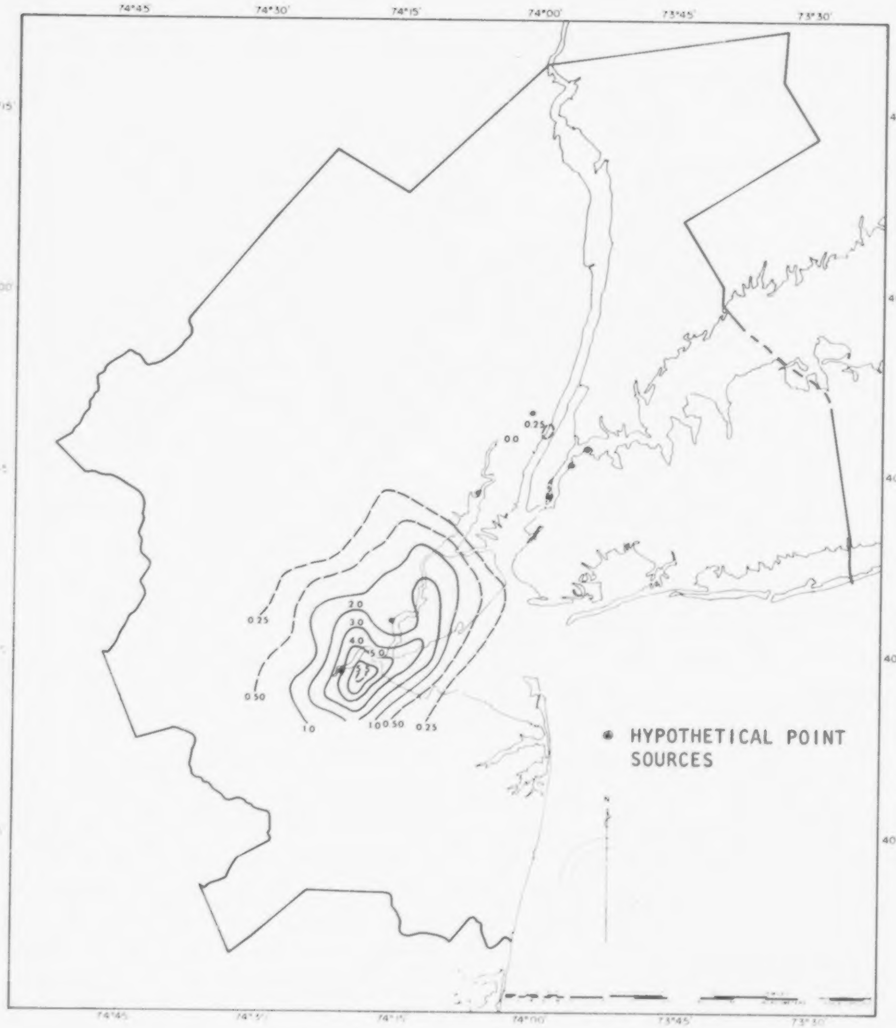
0.25
0.1
0.25
2.0
3.0
3.0
4.0
5.0
0.25
0.25
0.25
0.5
1.0
1.0
0.5
0.25
● HYPOTHETICAL POINT SOURCES

Figure 17. Theoretical percent frequency of occurrence of short-term particulate concentrations ≥ 50 μg/m^3 based on seven hypothetical point sources and on wind roses for January through May 1967.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0.0
0.25
2.0
3.0
4.0
5.0
0.50
1.0
1.0
0.50
0.25
HYPOTHETICAL POINT SOURCES

Figure 18. Theoretical frequency of occurrence of short-term particulate concentrations $\geq 50\ \mu g/m^3$ based on seven hypothetical point sources and on climatological wind roses for January through May 1951-1960.

III. DISCUSSION

IMPACT OF PARTICULATE POLLUTION ON STUDY AREA

Iso-intensity maps were constructed for each of the types of air pollutant measurements made in this survey. These were based upon the 50th percentile values calculated from the data obtained at each of the sampling stations. As would be expected, the patterns of pollutant iso-intensity lines are generally similar to those plotted from emissions data obtained in the inventory of sources.

The iso-intensity map for suspended particulate high-volume samples appears as Figure 19. This map shows one area centered about Newark, New Jersey with concentrations in excess of 125 micrograms per cubic meters at least 50 percent of the time. Surrounding this area and encompassing the central core of the study area (centered on the Hudson River) is a large area where suspended particulate values range from 100 to 125 micrograms per cubic meter. Outlying, predominantly residential, sections of the study area generally experience annual geometric averages of less than 75 micrograms per cubic meter.

Geographical distribution of suspended particulate sulfate is shown in Figure 20. The highest concentration area (20-25 ug/m^3) is found to be centered in lower Manhattan and extends eastward into Brooklyn and westward into New Jersey. Values in the range of 15 to 19 micrograms per cubic meter were found to be the most widely distributed. Outlying areas, which are predominantly residential, are shown to fall within the 10 to 14 micrograms per cubic meter range.

The geographic distribution of suspended acid particulate is given in Figure 21. The area of highest concentrations closely resembles that of the highest sulfate area; however, the mid-range for acid particulate (4 to 6 micrograms per cubic meter) is not nearly so extensive.

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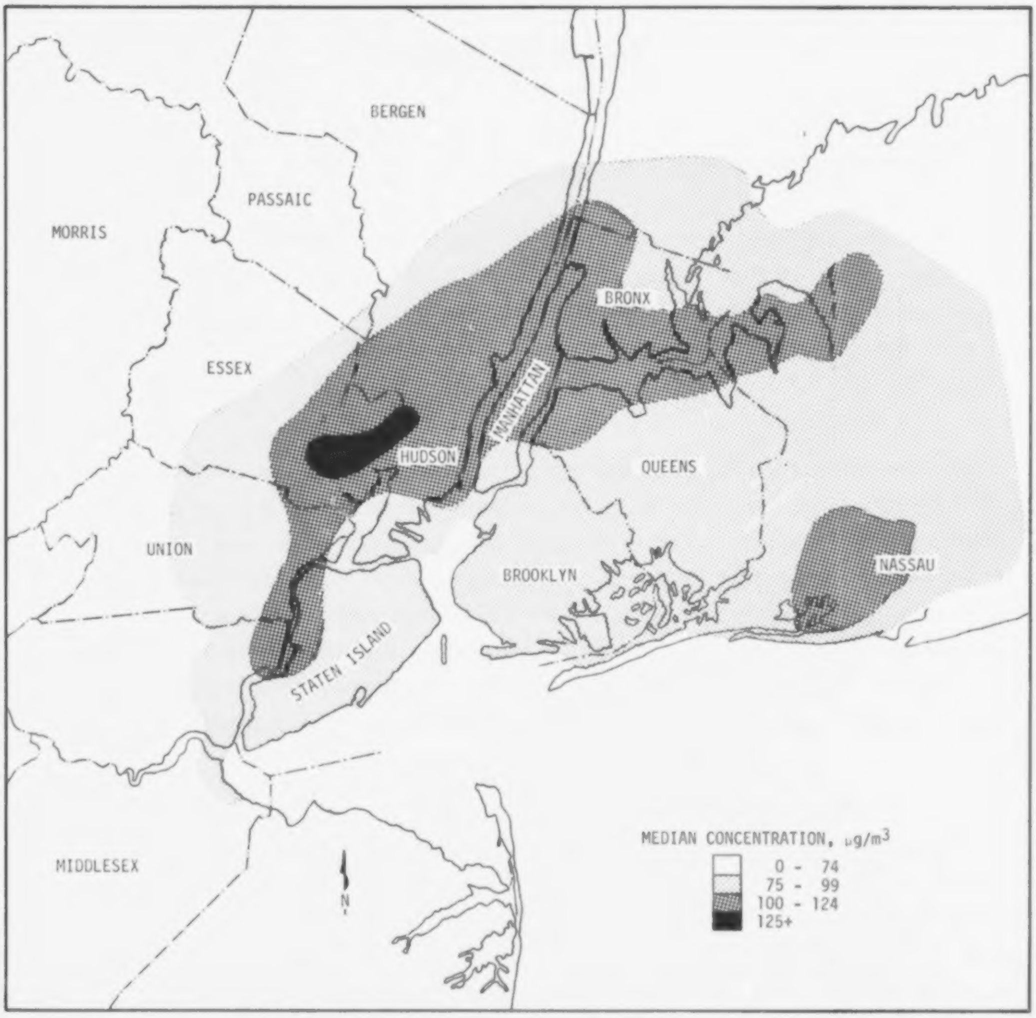
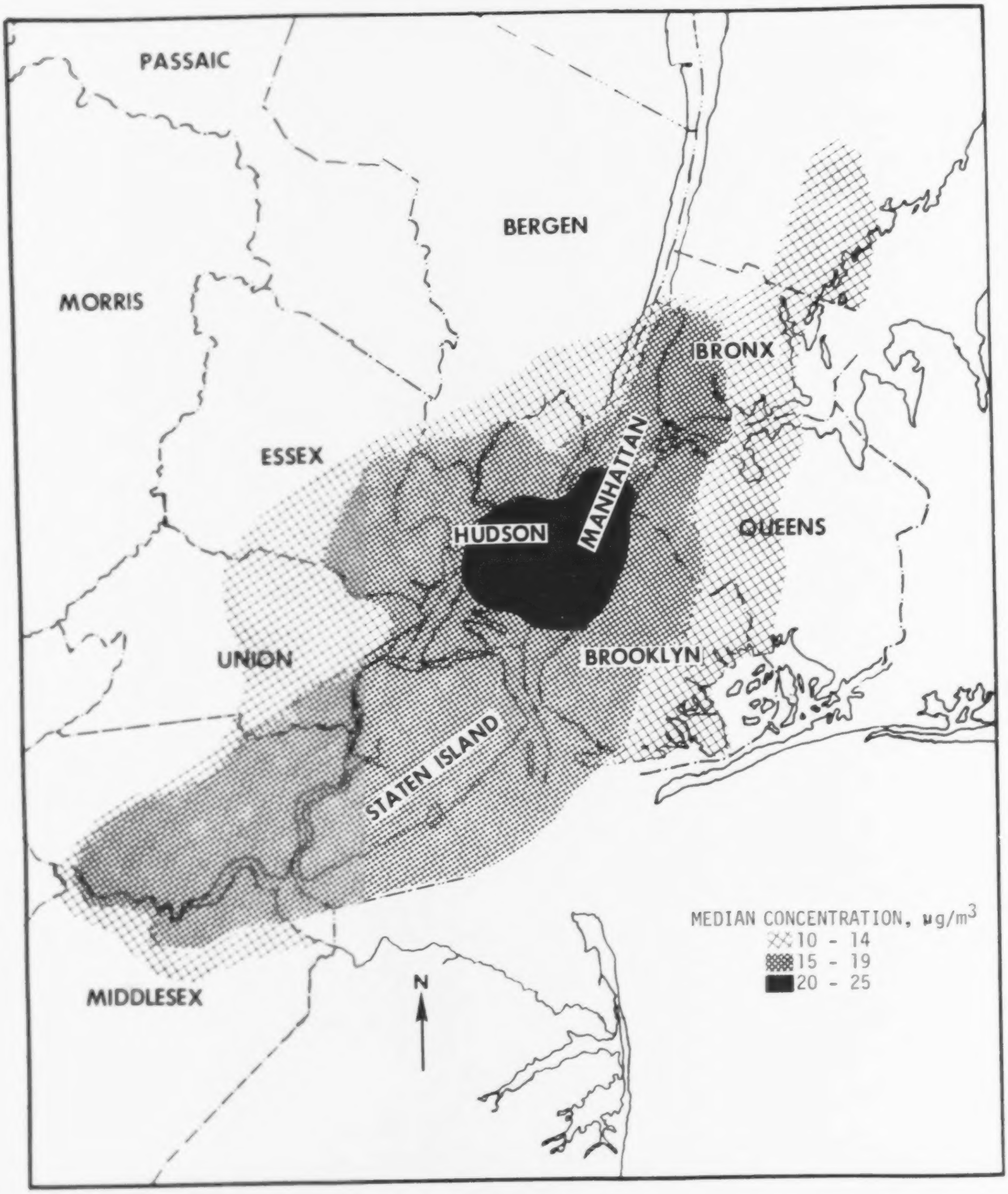

BERGEN
PASSAIC
MORRIS
ESSEX
BRONX
MANHATTAN
HUDSON
QUEENS
UNION
BROOKLYN
NASSAU
STATEN ISLAND
MIDDLESEX
N
MEDIAN CONCENTRATION, μg/m3
0 - 74
75 - 99
100 - 124
125+

Figure 19. Geographical distribution of suspended particulate measured by high-volume sampler.


PASSAIC
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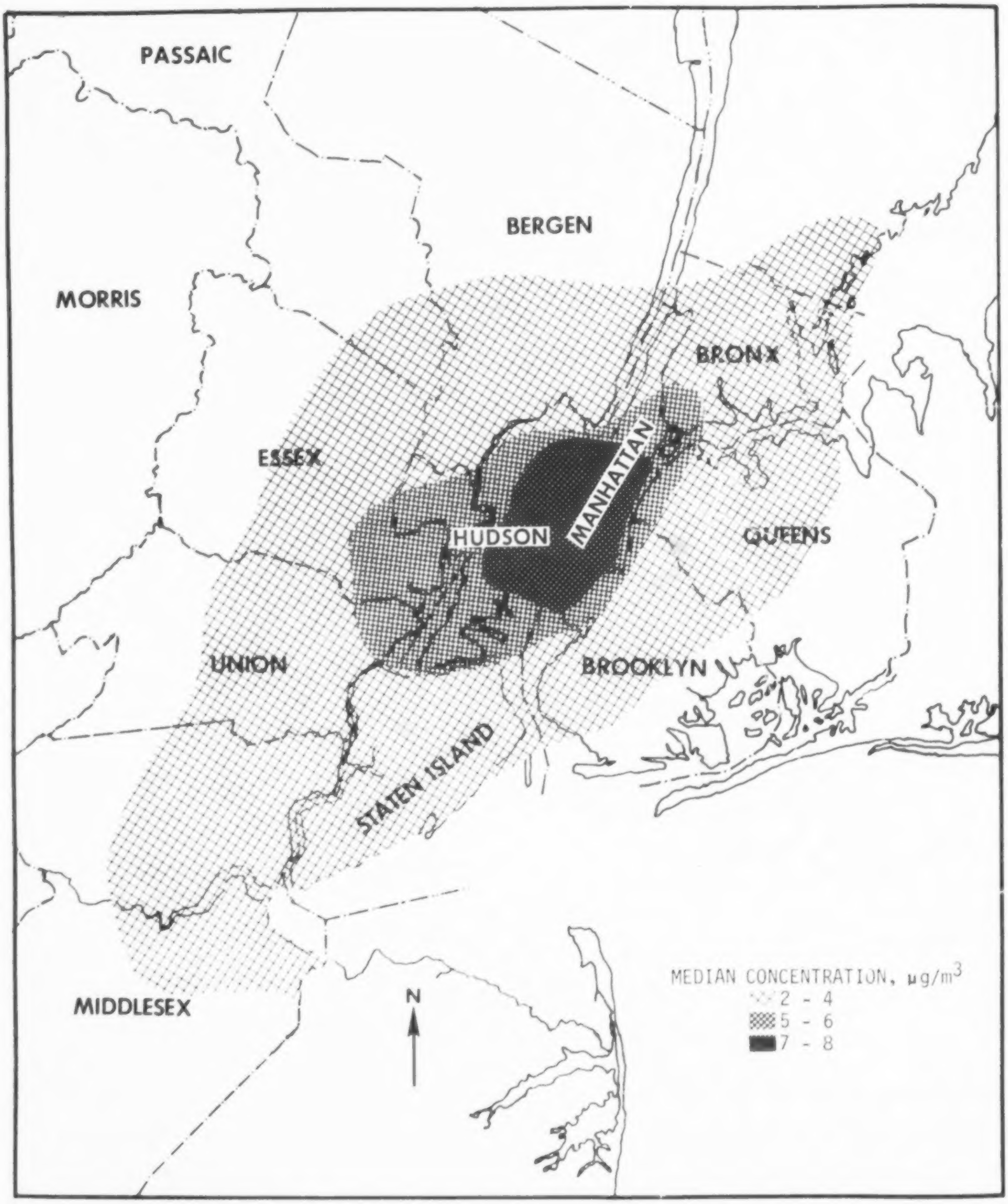
MORRIS
ESSEX
BRONX
MANHATTAN
HUDSON
QUEENS
UNION
BROOKLYN
STATEN ISLAND
MIDDLESEX
N
MEDIAN CONCENTRATION, µg/m³
▨ 10 - 14
▩ 15 - 19
■ 20 - 25

Figure 20. Geographical distribution of sulfate suspended particulate.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MORRIS
BRONX
ESSEX
MANHATTAN
HUDSON
QUEENS
UNION
BROOKLYN
STATEN ISLAND
MIDDLESEX
N
MEDIAN CONCENTRATION, μg/m3
2 - 4
5 - 6
7 - 8

Figure 21. Geographical distribution of acid suspended particulate.

Distribution of soiling index measured by the AISI sampler is given in Figure 22. The highest values center around the Newark area where there is major industrial activity. Data from this area covers the range of 2.0 to 2.9 Cohs per 1,000 lineal feet, which is rated as heavy soiling. The area with a range of 1.0 to 1.9 Cohs, identified as moderate soiling, generally extends eastward from the area of highest concentration, into practically all of the Bronx, and into portions of upper Queens.

Areas of settleable particulate (dustfall) concentrations greater than 35 tons per square mile per month center on Manhattan and extend westward along the New Jersey side of the Hudson River and eastward into the Bronx, Brooklyn, and Queens (Figure 23). Another area of high values is found in the Rockaway area around Queens (No. 163). Generally, however, values decrease from highs of greater than 75 tons per square mile per month (50th percentile) in the inner core area to less than 10 tons per square mile in outlying residential areas.

SUMMARY OF PARTICULATE AIR POLLUTION STANDARDS, CRITERIA, AND OBJECTIVES

Air quality standards, criteria, or objectives summarized in Table 36 have been taken from published documents and reflect the status of such standards as of July 1, 1967.

COMPARISON OF CURRENT LEVELS WITH STANDARDS OR OBJECTIVES

Suspended Particulate - High-Volume Sampler

Data obtained from the 17 locations in the study area were compared with established air quality standards or objectives to determine the extent that study area pollutants exceed levels acceptable to states.

Fourteen of the 17 stations exceed the objectives set by the State of New York either at the 50th percentile, 84th percentile, or both. Newark (No. 007) exceeds to the greatest degree followed by 121st Street, Manhattan (No. 014), and mid-Manhattan (No. 025).

Figure 24 graphically represents the degree that each station meets or exceeds the Ambient Air Quality Objectives of the State of New York.

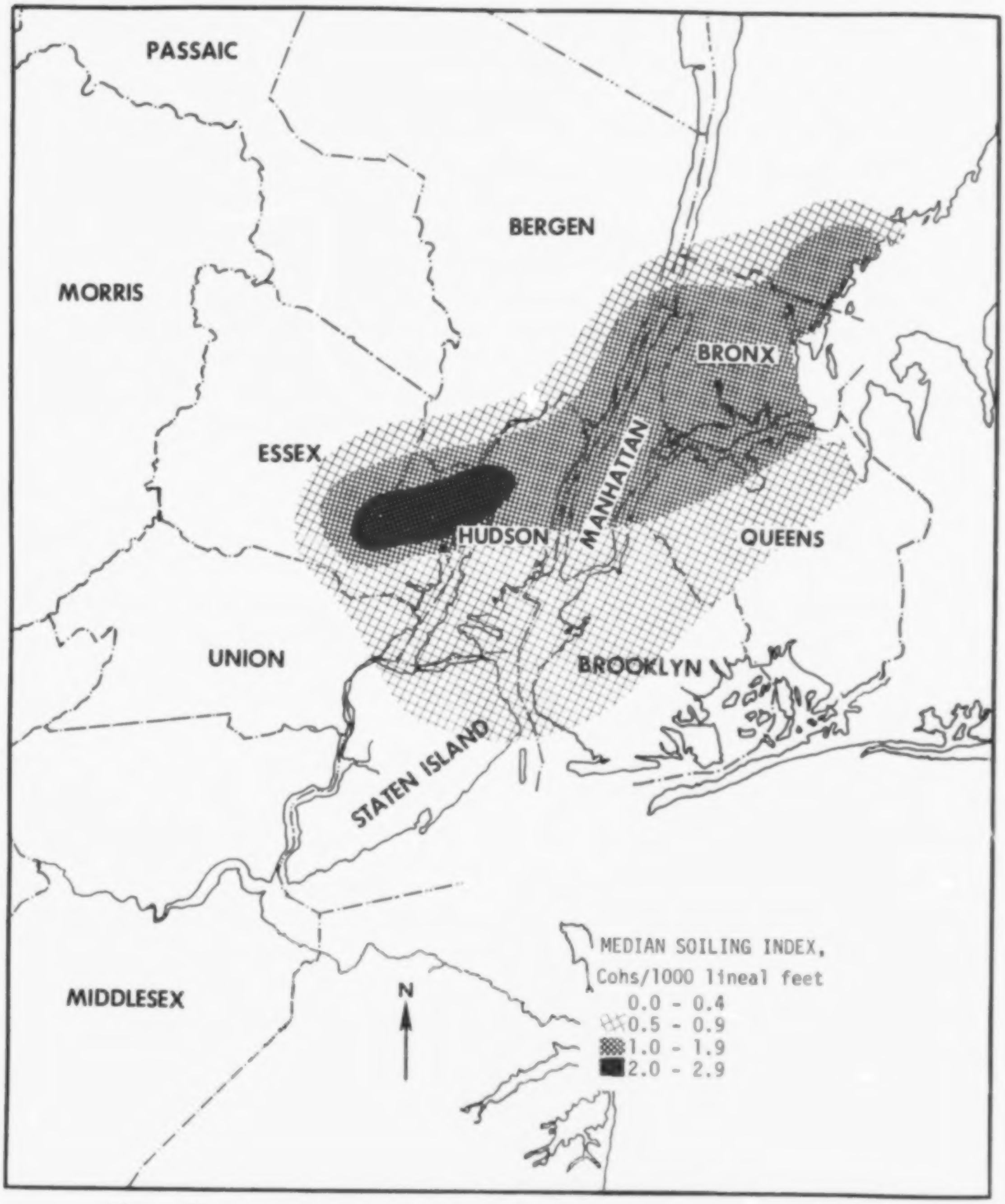

PASSAIC
BERGEN
MORRIS
BRONX
ESSEX
MANHATTAN
HUDSON
QUEENS
UNION
BROOKLYN
STATEN ISLAND
MIDDLESEX
N
MEDIAN SOILING INDEX,
Cohs/1000 lineal feet
0.0 - 0.4
▨ 0.5 - 0.9
▩ 1.0 - 1.9
■ 2.0 - 2.9

Figure 22. Geographical distribution of suspended particulates (soiling index) measured by AISI sampler.

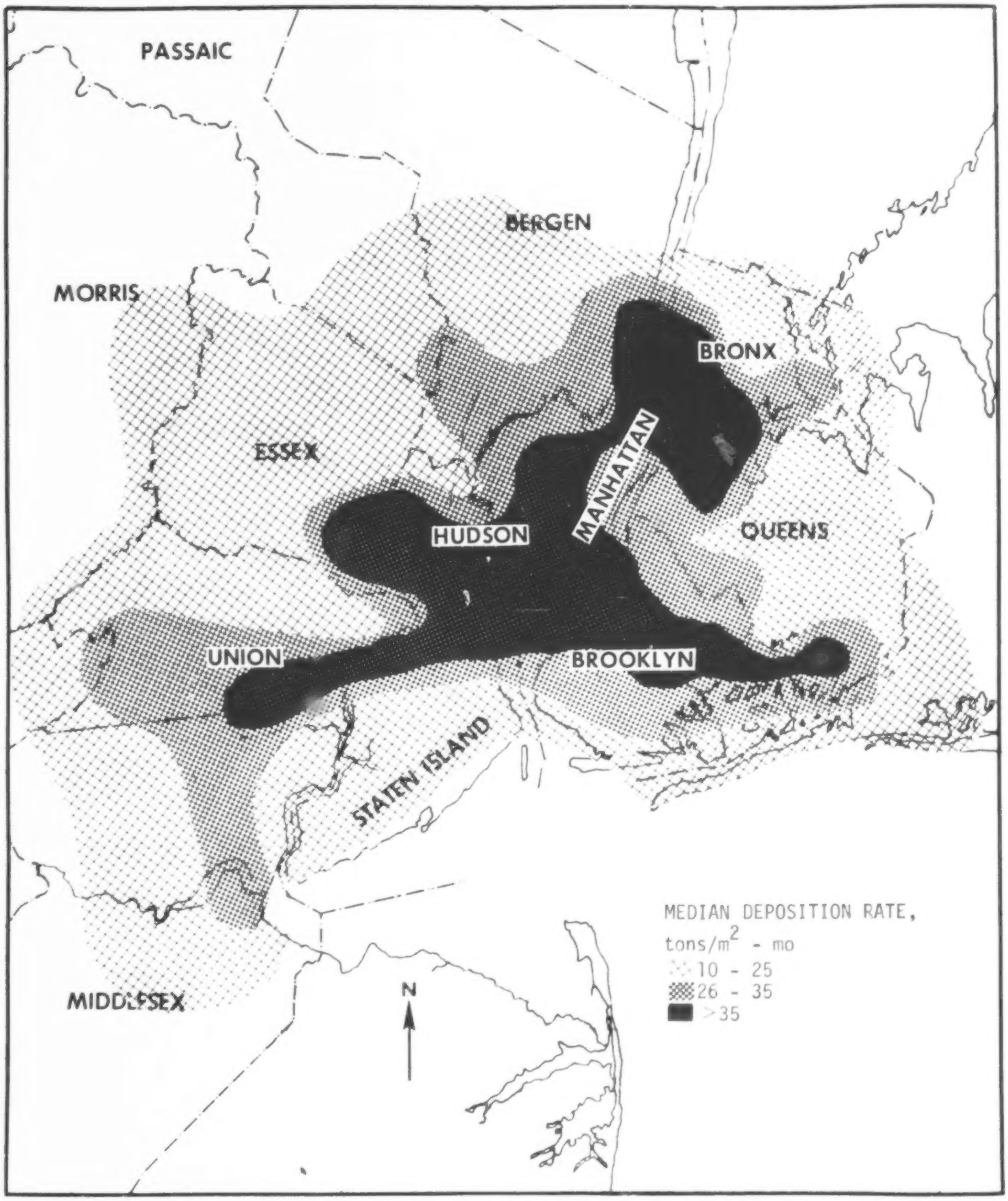

PASSAIC
BERGEN
MORRIS
BRONX
ESSEX
MANHATTAN
HUDSON
QUEENS
UNION
BROOKLYN
STATEN ISLAND
MIDDLESEX
N
MEDIAN DEPOSITION RATE,
tons/m^2 - mo
10 - 25
26 - 35
>35

Figure 23. Geographical distribution of settleable particulate - dustfall.

Table 36. AIR QUALITY STANDARDS, CRITERIA, AND OBJECTIVES

Suspended Particulate - High-Volume Sampler

State of New York[5]

Regional Objective "C" Subregion 3 (New York City and Portions of Westchester and Nassau Counties)

80 micrograms/m^3 (24-hr. avg.) 50% of values less than
120 micrograms/m^3(24-hr. avg.) 84% of values less than

Regional Objective "C" Sub-region 2 (Portions of Westchester and Nassau Counties)

65 micrograms/m^3 (24-hr. Avg.) 50% of values less than
100 micrograms/m^3 (24-Hr. Avg.) 84% of values less than

Suspended Particulate - Soiling - AISI Sampler

State of New Jersey[6]

Adjectival Rating Scale (Not a Standard)

0 - 0.9 Coh per 1000 Lineal Feet - Light
1.0 - 1.9 Coh per 1000 Lineal Feet - Moderate
2.0 - 2.9 " " " " " - Heavy
3.0 - 3.9 " " " " " - Very Heavy
4.0 - plus " " " " " - Extremely Heavy Soiling

Settleable Particulate - Dustfall

State of New York[5]

Regional Objective "C" Sub-region 3 (New York City and Portions of Westchester and Nassau Counties)

0.90 mg/cm^2/mo (25.7 tons/mi^2/mo) - 50% of values less than
1.20 mg/cm^2/mo (34.3 tons/mi^2/mo) - 84% of values less than

Regional Objective "C" Sub-region 2 (Portions of Westchester and Nassau Counties)

0.60 mg/cm^2/mo (17.1 tons/mi^2/mo) - 50% of values less than
0.80 mg/cm^2/mo (22.8 tons/mi^2/mo) - 84% of values less than

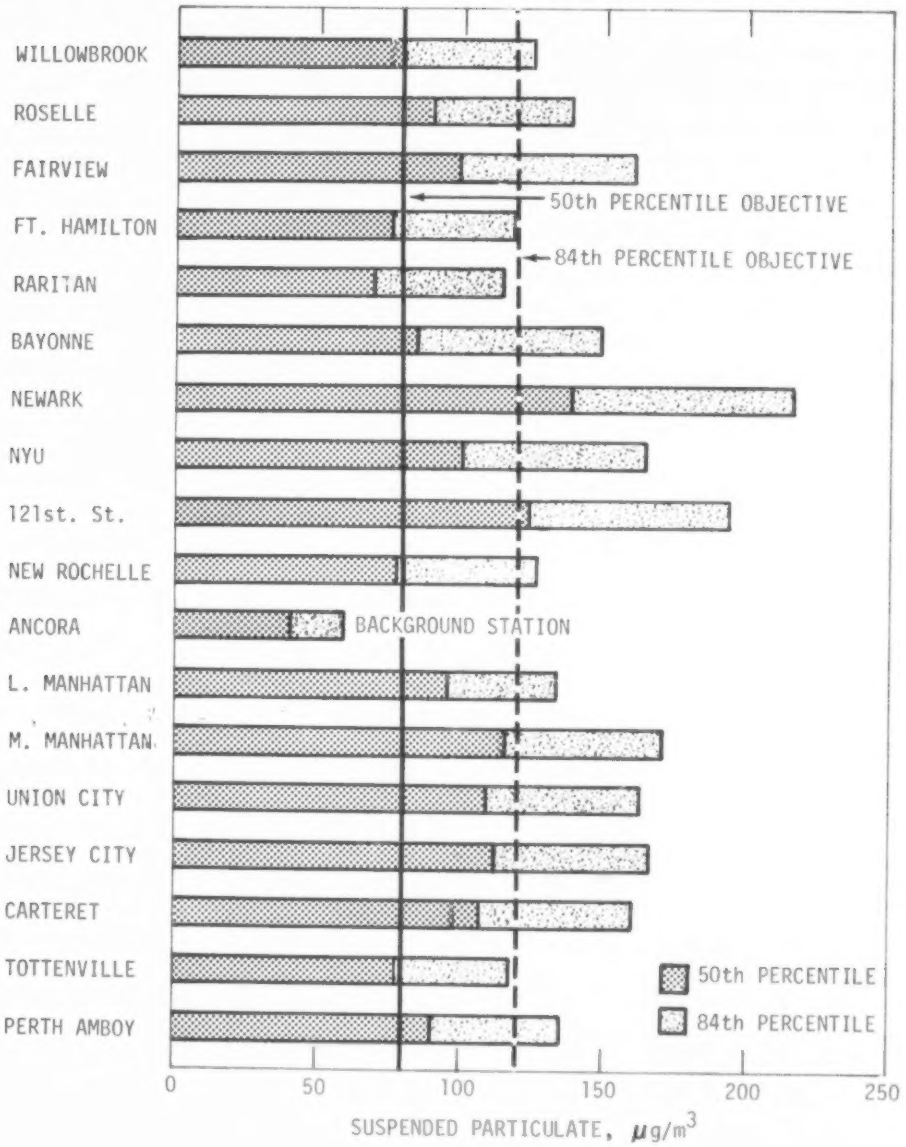


Figure 24. Comparison of suspended particulate (high-volume sampler) at various study stations with ambient air quality Objective C Subregion 3 of State of New York.

Suspended Particulate - AISI Sampler

The State of New Jersey has proposed an adjectival rating system that may be used as a guide to classifying soiling conditions in areas of measurement. This system permits classification of soiling in 5 ranges from "Light" to "Extremely Heavy".

Using this adjectival rating system, Newark (No. 007) and 121st Street, Manhattan (No. 014) would be rated areas of heavy soiling; Bayonne (No. 006), New York University (No. 012), Central Park (No. 013) and New Rochelle would be classified as areas of moderate soiling. The data are depicted in Figure 25.

Settleable Particulate - Dustfall

Ambient air quality standards as adopted by the State of New York for Objective "C", Subregion 3, are 0.90 mg/cm^2-mo (25.7 $tons/mi^2$-mo), 50 percentile and 1.20 mg/cm^2-mo (34.3 $tons/mi^2$-mo), 84th percentile. Figure 26, which compares the survey data with these standards, shows that these standards are exceeded at 34 of the 55 sampling sites.

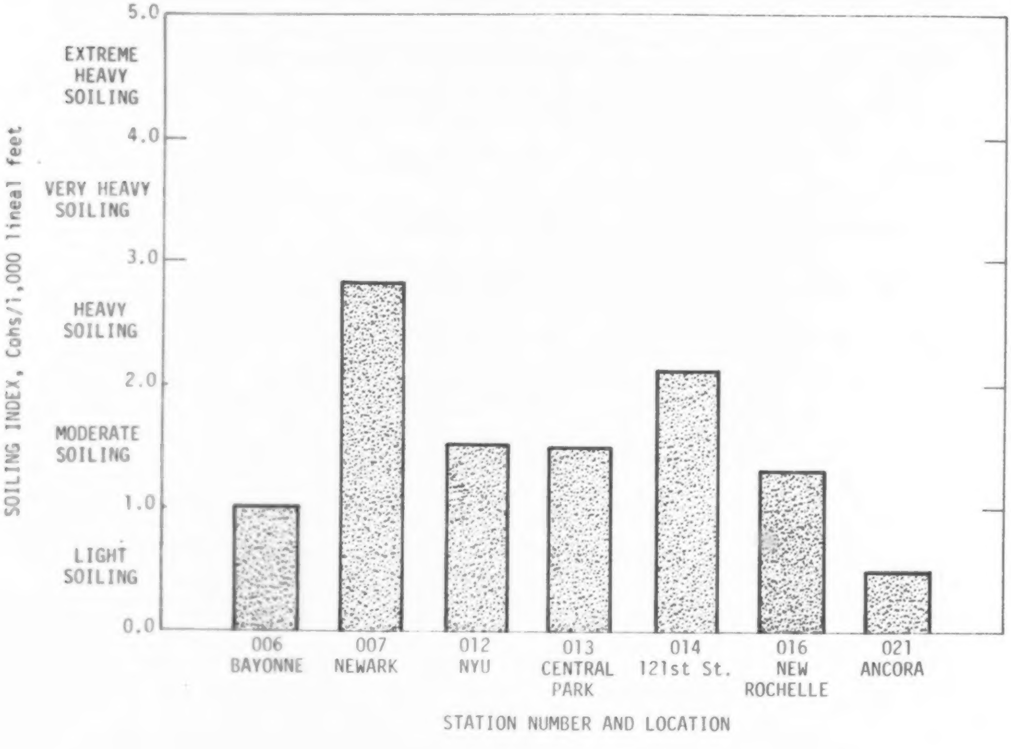
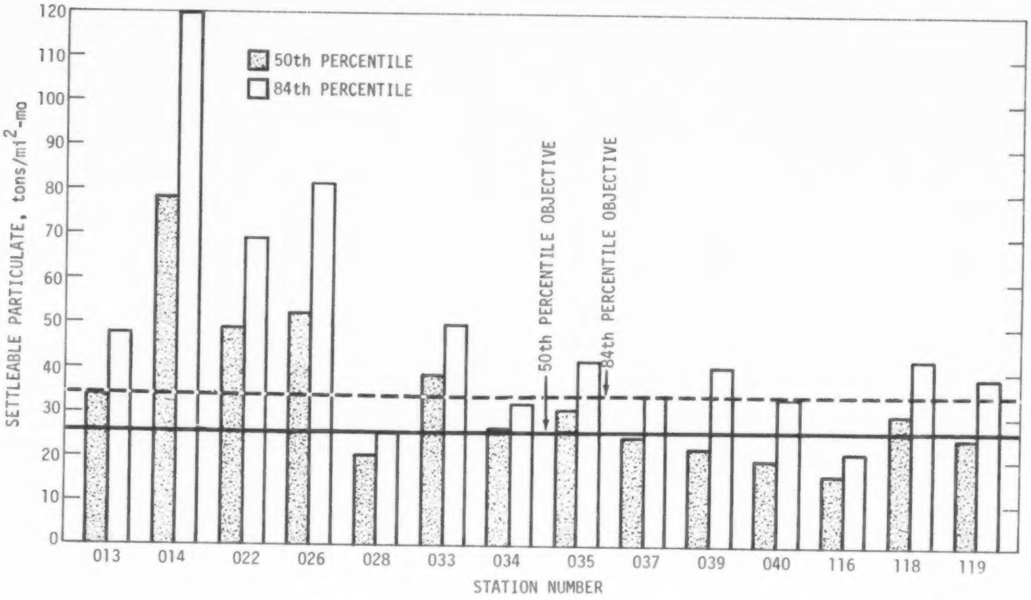


Figure 25. Comparison of New Jersey objectival rating system with average values at study stations.



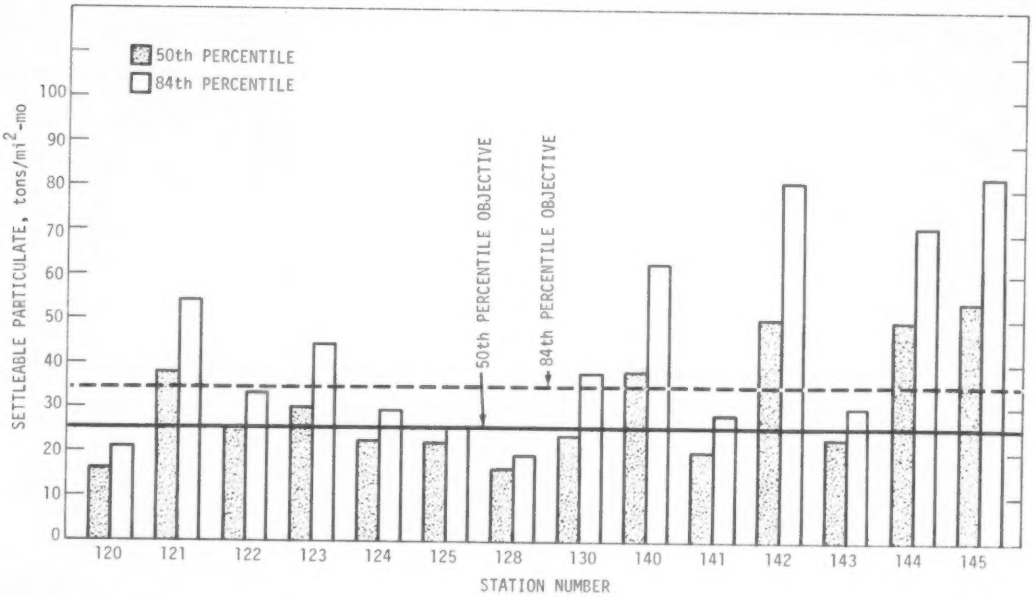


Figure 26a. Comparison of settleable particulates (dustfall) at study area stations with New York State ambient air quality Objective C for Subregion 3. (stations 013-145)

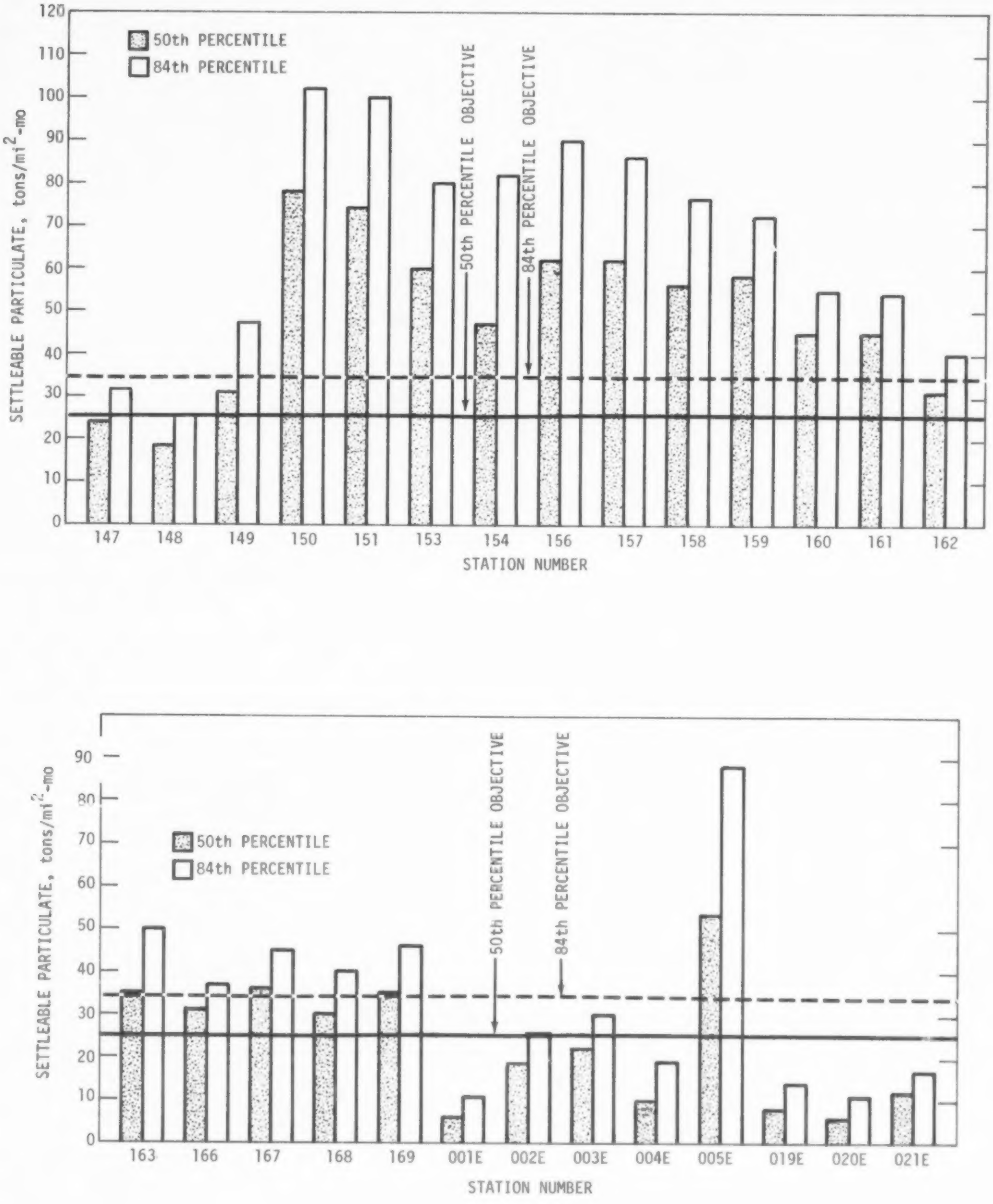


Figure 26b. Comparison of settleable particulates (dustfall) at study area stations with New York State ambient air quality Objective C for Subregion 3. (stations 147-021E)

ANTICIPATED REDUCTIONS IN PARTICULATE EMISSIONS

State and local air pollution control regulations, both existing and pending, will require reductions in particulate emissions in New York and New Jersey. In addition, major utility and industrial sources have initiated programs to reduce particulate pollution from coal burning and industrial processes. Some of these decreases are being accomplished in 1967; others are not expected until 1971. The anticipated reductions will be brought about by installation and improvement of dust collectors, upgrading of incinerators, elimination of inefficient incinerators and some changes in fuel use.

Pertinent control regulations include: (1) those which limit particulate discharges directly as a function of process weight, stack height, heat input or the rate of refuse burning; (2) those which require control equipment of specific efficiency; and (3) those which limit particulate emissions indirectly through the setting of fuel-sulfur standards. Most of the direct particulate regulations are already in force. Fuel-sulfur regulations have been adopted in New York State and New York City and are under study in New Jersey. These fuel-sulfur regulations are expected to decrease coal burning particulates as the result of fuel treatment, effluent control of sulfur dioxide, and switches to other fuels.

Prediction of the methods that will be employed to meet existing and pending control regulations is difficult. State fuel-sulfur standards, all of which are not yet finalized, could be implemented in several ways, some of which would restrict particulate emissions more than others. The largest decrease would take place if all high-sulfur coal and oil were replaced with natural gas. However, a complete change to natural gas is not expected.

Table 37 was developed to show the effect of existing regulations and planned improvements on particulate emissions. These figures reflect what would have been discharged to the atmosphere if the standards and improvements had been in effect in 1966. Major assumptions are:

1. The Public Service Electric and Gas Company will replace 32 percent of its current coal consumption with low-sulfur oil in late 1967 and cease burning coal at its three least efficient stations. Its new coal-fired unit to be

Table 37. ANTICIPATED REDUCTIONS IN 1966 PARTICULATE DISCHARGES IN STUDY AREA

	New Jersey			New York City			Outer New York counties			Study area		
Source	Emissions 1966,tons	Change, %	Governing reason	Emissions 1966,tons	Change, %	Governing reason	Emissions 1966,tons	Change, %	Governing reason	Emissions 1966,tons	Change, %	Resultant emissions
Bituminous coal-power plants	13,000	-33[a]	Voluntary company action in 1967	15,200	-37[d]	NYC-APC Code 909-b (existing)	3,500	NC	--			
					-51[d]	NYC Law #14 effective 5-20-69				31,700	38	19,600
Bituminous coal-other	11,300	-70[b]	NJ Chapt. X Step 1	2,800	-100[e]	Code 909-b Law #14 & pending NYS Rule 200.	6,200	-100[g]	Nassau Co. Law #1-1967, & NYS Rule 200.			
		-80[b]	Chapt. X Step 3, 10-1-71							20,300	89	2,300
Anthracite coal	15,700	-95[b]	Chapt. X Step 3, 10-1-71	12,700	-100[e]	Code 909-b & NYS Rule 200.	600	-508	Nassau Co. Law #1-1967,	29,000	-96	1100
Refuse burning	5,400	NC	--	27,200(1)	-81[f]	Law #14 & Code 909-a	9,000	-64[h]	Nassau Co. Law #1-1967, & NYS Rule 194.4, Pt.5	41,600	-67	14,000
Industrial processes	14,500	-10	NJ Chapt. VII & other	1,300	-10	Code 9.03 & 909-c	4,100	-10	Nassau Co. Law #1-1967, & pend. NYS Rule 187	19,900	-10	17,900

Table 37 (continued). ANTICIPATED REDUCTIONS IN 1966 PARTICULATE DISCHARGES IN STUDY AREA

Source	New Jersey			New York City			Outer New York counties			Study area		
	Emissions 1966, tons	Change, %	Governing reason	Emissions 1966, tons	Change, %	Governing reason	Emissions 1966, tons	Change, %	Governing reason	Emissions 1966, tons	Change, %	Resultant emissions
Distillate oil	8,800	+ 8[c]	Replace coal	8,300	+ 5[c]	Replace coal	2,900	+ 5[c]	Replace coal Nassau Co.	20,000	+ 6	21,100
Natural gas	1,700	+ 8[c]	Replace coal	1,500	+ 8[c]	Replace coal	500	+ 6[c]	Replace coal Nassau Co.	3,700		4,000
Residual oil	13,500	NC	--	14,700	NC	--	1,400	NC	--	29,600	NC	29,600
Gasoline	9,400	NC	--	8,000	NC	--	5,300	NC	--	22,700	NC	22,700
Diesel fuel	6,500	NC	--	3,700	NC	--	1,000	NC	--	11,200	NC	11,200
Aircraft & ships	200	NC	--	1,300	NC	--	--	--	--	1,500	NC	1,500
All sources	100,000	-29 % to 71,100 tons 10-1-71		96,700	-47 % to 49,700 tons 5-20-69		34,500	-35% to 22,500 tons 10-1-69		231,200	-37%	145,000 1971

[a] Reflects reduction in coal burning and elimination of some power plant boilers with low efficiency collectors, increase due to new unit at Hud. Sta. in 1968.

[b] Reductions in coal burning assumed to meet sulfur limits of Chapter X of N. J. Code.

[c] Assumes coal is replaced with distillate oil and natural gas in equal portions (gross heat basis).

[d] Will reflect increases in collection efficiency to 98% maximum, no appreciable decrease in coal burning at NYC power plants.

[e] Assumes none of "other" coal-fired boilers can meet limits of Code 909-b or Public Law #14 and won't be upgraded with high efficiency collectors.

[f] Assumes all on-site NYC incinerators will be limited to 4 pound particulate per ton refuse, municipal units 2.6 pound/ton refuse.

[g] Reductions in coal burning assumed to meet sulfur limits of pending New York State Rule 200 as well as Nassau Law #1-1967 re particulate emissions.

[h] New York State Rule 194.4 effectively would limit particulates to 10 pound/ton refuse at all existing units; Nassau County Law #1-1967 limits are effectively 6 pound/ton at on-site and 4 pound/ton refuse at municipal incinerators.

[i] Includes harbor area refuse.

operative at the Hudson Station in 1968 is reported to be the last coal-burning unit to be installed by the Company in the survey area.

2. Other electric utilities will continue to burn coal at the same yearly rate as in 1966.
3. Particulate collectors rated at 99 percent collection efficiency as required to be used by New York City's Law No. 14 are assumed to operate at 98 percent average efficiency.
4. **Displaced "other" bituminous coal and anthracite coal will be replaced on a 1:1 basis with natural gas and distillate oil.**
5. There will be no net change in residual oil burning.
6. The quantity of refuse burned in each area will remain the same although incinerators will be upgraded.
7. Pending state regulations will be enacted without major changes.
8. All state and local regulations will be enforced.

Under the above assumptions, 1966 particulate emissions could be reduced by 37 percent, or 86,200 tons. The largest fractional decrease, 47 percent, would occur in New York City principally because of Public Law No. 14 and Section 909 of the Air Pollution Code. These regulations would be expected to eliminate all coal burning except at power plant boilers, and to require the marked upgrading of almost all incinerators, as well as improvements in several power plant dust collectors. The upgrading program at Consolidated Edison's power plants is already under way. There is less certainty that incinerator improvements will meet target dates. New York City's limits on incinerator emissions are more stringent than those of any other jurisdiction in the area, but compliance to date has been only minimal.

The calculated 35 percent reduction of particulate emissions in Nassau, Rockland, and Westchester Counties would come about as a result of fuel-sulfur and incinerator standards. New York State's Rule 200 contains a sulfur limit for space-heating fuels well below that of almost all present bituminous coal supplies. A change to natural gas and fuel oil would show a moderate decrease in generation of particulates. Nassau County's law No. 1-1967 would also eliminate uncontrolled coal burning by establishing particulate discharge limits. The incinerator standards of Nassau County are more stringent than those of the State code for existing units. Most incinerators in Nassau, Rockland, and Westchester will require upgrading to meet either standard.

In New Jersey, almost all of the estimated 29 percent decrease in emissions of particulates would occur as a result of the fuel-sulfur control program. A significant reduction took place in 1967 when the Public Service Electric and Gas Company replaced coal with low-sulfur oil at three stations equipped with low-efficiency collectors. These fuel changes were made in portions of the study area adjacent to Newark Bay and the Arthur Kill where there are relatively heavy pollutant emissions. The new unit at the Hudson Station of Public Service Electric and Gas Company will be coal-fired, but the dust collectors will be of high efficiency. New Jersey's pending control regulation-Chapter X-is expected to effect major reductions in coal burning through the establishment of fuel-sulfur standards. These decreases would be anticipated earlier (1968) for bituminous than for anthracite coal (1971). Most anthracite coal can meet the First Step sulfur limit of Chapter X.

The increase or decrease of particulate emissions in the study area by the time the above-noted control regulations are fully implemented in 1971 depends on several variables. Of prime concern will be the competition expected among the coal, oil, and natural gas industries to supply the requisite low-sulfur fuel needs of the area. On an equivalent heat basis, the most efficiently controlled coal-burning operations produce more particulate than oil combustion and significantly more than natural gas.

Using the foregoing calculated reductions, projected emission levels based on anticipated population expansion[7] were developed. These projections, shown in Figure 27, indicate a level of approximately 152,000 tons per year of particulate emissions in 1971. The figures would rise to about 177,000 in 1985. Much of this population and pollution expansion would be in areas which are presently rural.

EFFECTS OF ANTICIPATED REDUCTIONS IN PARTICULATE EMISSIONS

As indicated previously, a significant reduction in particulate emissions can be anticipated in portions of the 17 county area. To estimate the effect these reduced emissions will have on air quality throughout the abatement area, theoretical determinations of particulate concentration at selected locations were made. These were accomplished by utilizing the current 1966 and projected 1971 particulate emissions previously defined, and by imposing on the calculations a set of defined meterological conditions.

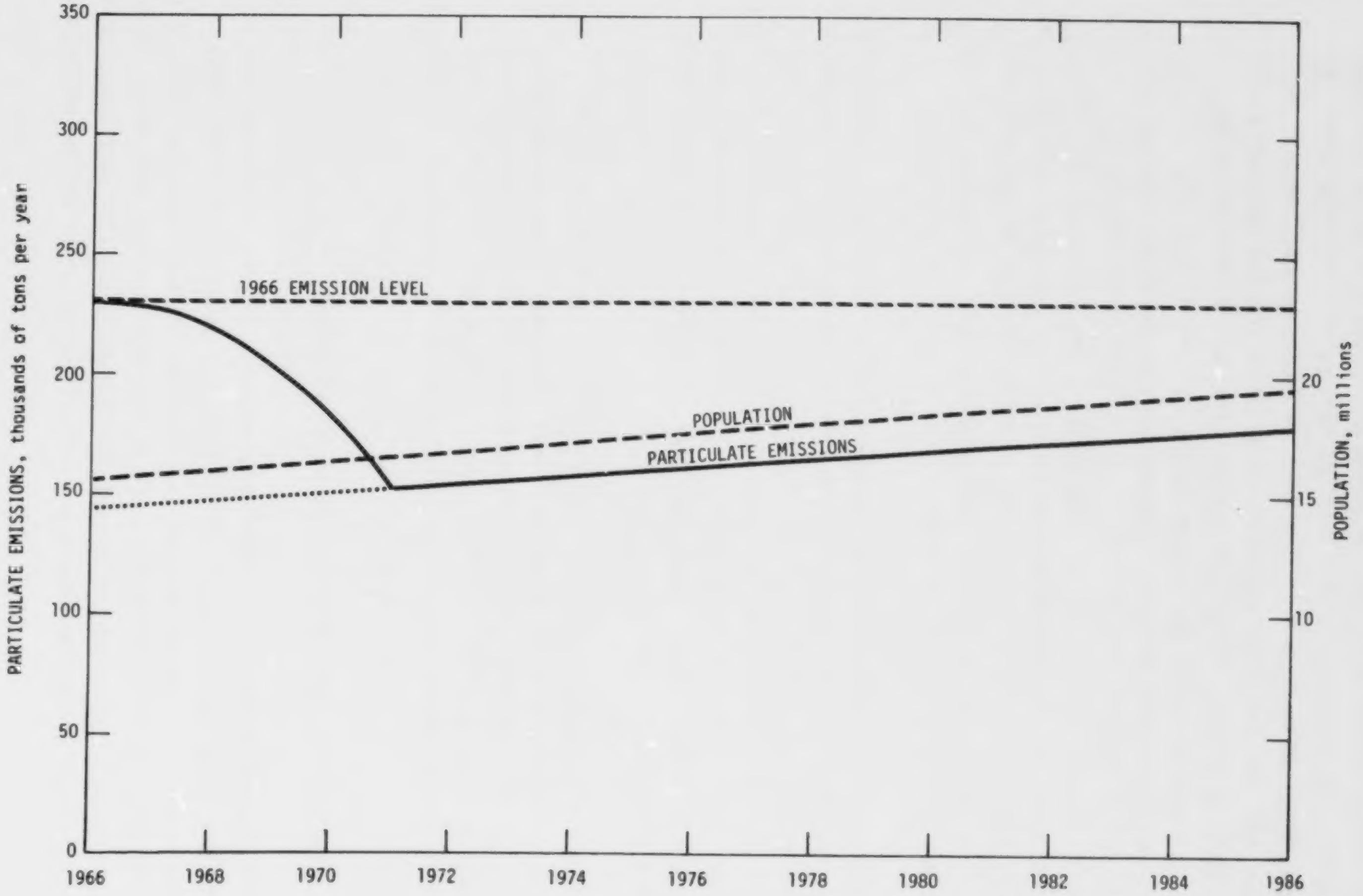


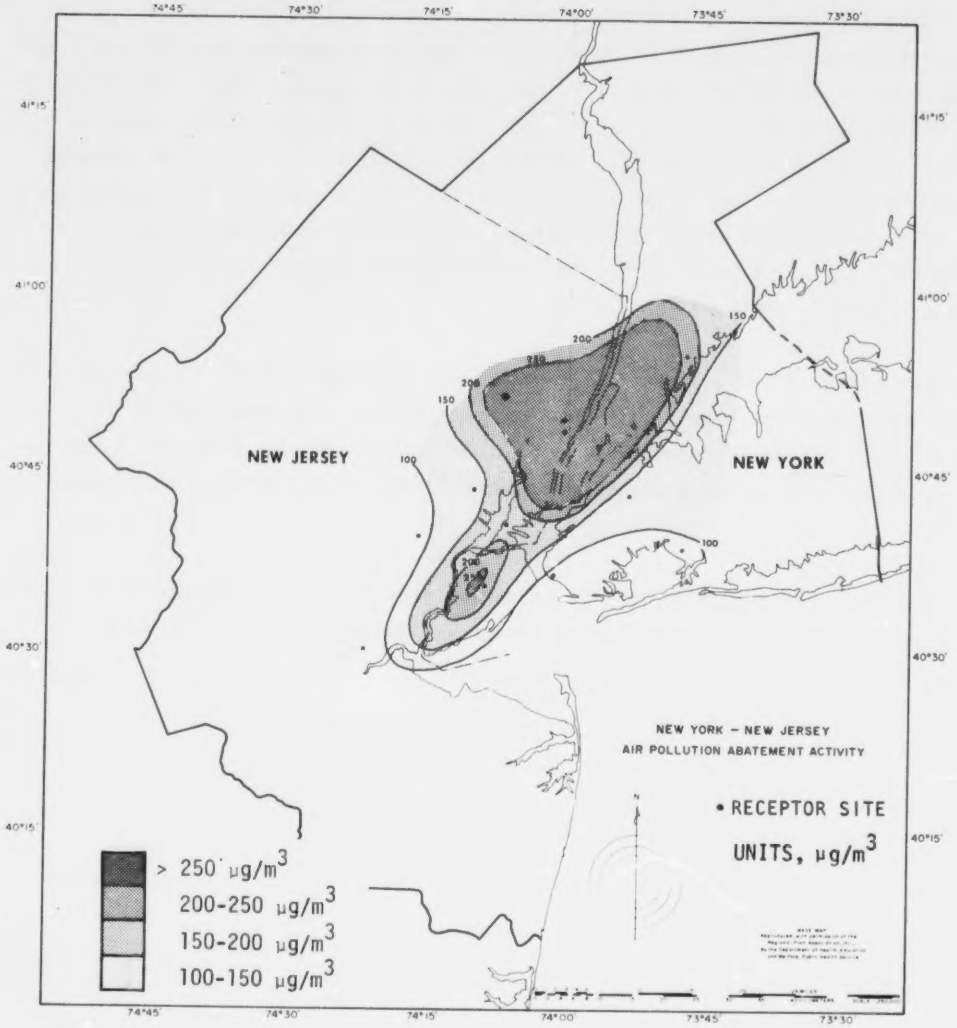
Figure 27 Projected particulate emissions in study area based on anticipated emission reductions and population increase.

Meterological conditions representing averages for an actual day in the early spring were taken for the calculations. An average wind direction of 215 degrees and an average wind speed of 4.3 meters per second were used. It was assumed that neutral stability existed all day and an inversion was based at an average height of 500 meters above the surface.

Using the Gaussian diffusion equation, as given by Gifford[8], the sum of all particulate concentrations which occur due to emissions from upwind point and area sources were determined for each of 11 representative receptor sites. This was done assuming continuous emissions from all sources at average yearly rates for both the current 1966 emission data and for the projected 1971 data; a background level of 75 micrograms per cubic meter was included at all sites. Iso-concentration plots of theoretical concentrations estimates for 1967 emission data, and theoretical concentration estimates for 1971 emission data, respectively, are displayed on maps in Figures 28 and 29.

Comparison of the 1971 estimates with those for 1966 reveals the same basic concentration pattern; however, if the proposed controls are accomplished the general levels will be reduced by as much as 30 percent in many areas and by 50 percent in the most polluted areas, i.e. upper Manhattan and northwestern Staten Island.

The indicated reduction in ambient contaminant levels should prevail a significant percent of the time, since the prevailing wind direction at both Central Park and Newark Airport is southwesterly for about six months of the year.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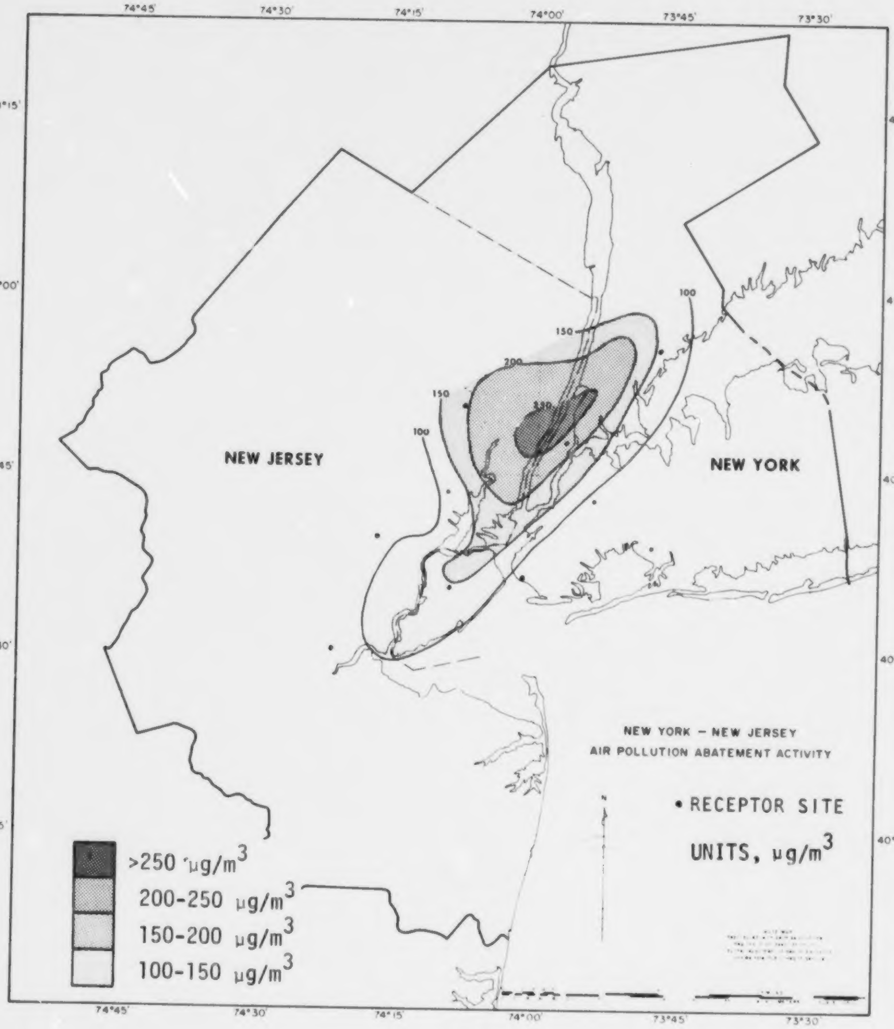
NEW YORK – NEW JERSEY
AIR POLLUTION ABATEMENT ACTIVITY
• RECEPTOR SITE
UNITS, μg/m3
N
> 250 μg/m3
200-250 μg/m3
150-200 μg/m3
100-150 μg/m3

Figure 28 Theoretical distribution of particulate concentrations based on April 2, 1967, weather data and 1967 emission data.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NEW YORK
100
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NEW YORK – NEW JERSEY
AIR POLLUTION ABATEMENT ACTIVITY
• RECEPTOR SITE
UNITS, µg/m3
>250 µg/m3
200-250 µg/m3
150-200 µg/m3
100-150 µg/m3

Figure 29 Theoretical distribution of particulate concentrations based on April 2, 1967, weather data and projected 1971 emission data.

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APPENDICES

Appendix A. Phase I Conclusions and Recommendations

Appendix B. Aerometry Operations and Techniques

Appendix C. Emissions Inventory Procedure

Appendix D. Pollutant Measurement Data

APPENDIX A. CONCLUSIONS AND RECOMMENDATIONS ON INTERSTATE AIR POLLUTION - NEW YORK - NEW JERSEY METROPOLITAN AREA, JANUARY 1967

General Conclusions Reached By Official Participants Of New York - New Jersey Metropolitan Area Interstate Air Pollution Abatement Conference

A. Occurrence of Air Pollution Subject to Abatement under the Clean Air Act

1. The predominant portions of air pollutants present in the State of New York and in the State of New Jersey are discharged within each respective State, and each would have a serious air pollution problem without the existence of the other. Also, however, pollutants discharged to the atmosphere in the State of New Jersey cross the boundary into the State of New York, and pollutants discharged to the atmosphere in the State of New York are transported into the State of New Jersey; hence, indigenous air pollution in either State is increased by transport of pollutants from the other State.

   The interstate New York - New Jersey metropolitan area, in fact, has a common air mass, and any discharge of pollutants into that air mass, regardless of point of discharge, causes or contributes to air pollution and may be carried indiscrimantly throughout the area, subject to the vagaries of wind and weather.

   The material presented at the conference establishes that such interstate movement of air pollutants includes particulate matter, sulfur oxides, hydrogen sulfide, mercaptans, and other compounds; but the record is insufficient to establish interstate movement of carbon monoxide.

2. Interstate air pollution in the New York - New Jersey metropolitan area causes or contributes to conditions which endanger health or welfare, as follows:

   a. It results in visibility restrictions endangering the safety of persons in interstate travel, both by land and by air, and it causes inconvenience and economic loss to the public and to transportation companies, due to disruption of traffic schedules.

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b. It causes damage to vegetation, including ornamental vegetation, with a consequent substantial economic and esthetic loss.

c. It results in the deterioration, damage and destruction of materials and property, including historical and architectural art objects and monuments, requiring additional expenditures for maintenance and replacement of materials.

d. It has multiple adverse economic effects on business and commercial operations.

e. The levels of sulfur dioxide monitored have been demonstrated to exceed consistently the objectives for 24-hour sulfur dioxide concentrations in community atmospheres adopted by the New York State Air Pollution Control Board for the New York State portion of the interstate metropolitan area, which also are recommended by the United States Public Health Service, (0.1 ppm 24-hour average of sulfur dioxide not to be exceeded more than 1 percent of the time).

f. At times, the actual concentrations of air pollutants in considerable portions of the area are at or above levels which have been observed in community situations to result in increased illness. Under certain meteorological conditions, these levels could, and have in the past, contributed to excess deaths.

3. Such interstate air pollution endangers the health and welfare of persons in New York and New Jersey, respectively, and is therefore subject to abatement under Section 105, Title I of the Clean Air Act (42 U.S.C. 1857, et seq.).

B. Adequacy of Measures Taken Toward Abatement of Air Pollution

Insufficient and inadequate action has been taken toward abatement of interstate air pollution in the 17-county New York - New Jersey metropolitan area.

There is no interstate regional agency with adequate authority to establish uniform air pollution control regulations and to assure coordinated uniform enforcement against all pollution sources located within the area.

The following actions relating to prevention, control and abatement of sulfurous air pollution have been taken by various jurisdictions in the bi-State metropolitan area:

Chapter VIII of the New Jersey State Air Pollution Control Code, which becomes effective March 1, 1967, limits the concentration and rate of emission of sulfurous compounds from industrial process operations. The conference has been assured that Chapter VIII will be vigorously enforced by the State of New Jersey. While this Chapter will prevent or eliminate some localized problems associated with industrial sulfurous emissions, it is not applicable to fuel-burning sources, which discharge more than 92 percent of the total sulfur oxides emitted in New Jersey. Chapter VIII will in no way abate the emission of sulfurous compounds from fuel burning, and it is doubtful that it will abate interstate air pollution from certain industrial process sources. Conference participants for the State of New Jersey are of the opinion, however, that the limitations on emission of sulfurous compounds from industrial process sources will be effective in eliminating problems caused by the interstate transport of sulfurous pollution from such sources.

The Interstate Sanitation Commission identifies point sources of interstate air pollution, investigates complaints, and supplies information to State and local agencies that is used in enforcement proceedings.

A New York City gas distributor, Brooklyn Union Gas Company, encouraged and supported by the New York City Department of Air Pollution Control, offers to large installations a special temperature-controlled, interruptible gas-distillate fuel oil rate. This system, if widely adopted, very significantly can reduce, at some increased cost, the sulfur-oxide emissions from non-power generating sources. It is unlikely that large-scale conversions to this system will be made voluntarily, however, and there was no indication that other gas utilities in the area intend to offer similar service. New York City is planning to convert the space heating of its municipal facilities to this system.

The City of Newark has announced that space heating for several of its municipal facilities will be provided by burning low-sulfur No. 2 distillate oil, instead of high-sulfur No. 6 residual oil.

The State of New York has adopted a system of ambient air quality objectives and, accordingly, has classified New York City and the surrounding New York counties of the metropolitan area. Also, it has adopted Rules to Prevent New Air Pollution, whereby it reviews and approves plans for construction or major reconstruction of facilities which may increase, decrease or alter air pollutant emissions. Under new authority, the New York State Air Pollution Control Board is empowered to promulgate emission standards and to regulate composition and use of fuels throughout the State.

New York City's Local Law 14 requires stepwise reduction in the maximum allowable sulfur content of fuels to 1 percent by 1971. The local electric utility, Consolidated Edison Company, which emits about 50 percent of the sulfur oxides in New York City, has been cooperating with City authorities by attempting to reduce sulfur content of its fuels well in advance of the mandatory schedule. Further, Consolidated Edison has submitted to the City a ten-year plan whereby its sulfur-oxide emissions to the City atmosphere would be significantly reduced; and, at the request of the City, Consolidated Edison has sought and found a means whereby low-sulfur oil can be obtained for use in its plants during the winter heating season when air pollutant concentrations in the New York - New Jersey area are highest. There is nothing in the record to show that similar action has been requested of or initiated by Consolidated Edison's counterparts in the New York portion of the interstate area or by Public Service Electric and Gas Company and Jersey Central Power and Light Company in the New Jersey portion.

Several municipalities in the metropolitan area have adopted and others contemplate the adoption of rules and regulations specifically designed to reduce sulfur-oxide emissions.

While each of these actions is designed to cope with a portion of the sulfur-oxide problem, they will not, individually or collectively, sufficiently alleviate this serious problem through the New York - New Jersey interstate metropolitan area to a point where health and welfare are not endangered.

C. Causes of Delay in Abating the Pollution

The States of New York and New Jersey have not conferred adequate authority in an interstate agency for adoption and enforcement of uniform standards and regulations. Consequently, standards, regulations and enforcement measures are neither uniform nor aimed at a common objective. Activities undertaken by individual jurisdictions in each State are designed to cope with portions of the problem arising within their borders; even if such actions were totally effective in abating pollution arising in a given jurisdiction, however, that jurisdiction still could suffer from air pollutants reaching it from other portions of the metropolitan area.

Recommendations By The Secretary, Department Of Health, Education, And Welfare

It is found that effective progress toward abatement of the air pollution discussed at this Conference is not being made, and that the health and welfare of persons in the 17-county area is being endangered. It is therefore recommended that necessary remedial action be taken. The following recommendations, it may be noted, were unanimously concurred in, except for Recommendation I. Regarding this Recommendation, all participants concurred in principle.

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RECOMMENDATION I
INTERSTATE AIR POLLUTION CONTROL AGENCY

In order to deal with the bi-State air pollution problem on a regional basis, an appropriate interstate agency must be vested with adequate legal authority. Such legislation for this purpose should provide:

1. Authority to establish ambient air quality standards for at least the 17-county area, i.e., Bergen, Essex, Hudson, Middlesex, Monmouth, Morris, Passaic, Somerset and Union Counties in the State of New Jersey; and the five counties of New York City as well as the counties of Nassau, Rockland, and Westchester in the State of New York;

2. Adequate rule-making power and enforcement authority to abate, control and prevent air pollution originating in at least the 17-county New York - New Jersey metropolitan area, and to make the maximum effective utilization of existing local resources for inspection and enforcement.

3. Effective representation of local governments in the 17-county bi-State area on State delegations and on the Interstate Agency, and

4. Federal representation on the Interstate Agency with the same vote as any State.

This Abatement Conference shall remain in continuing session, subject to the call of the Presiding Officer or his designated representative, until an interstate regional air pollution control agency with adequate legal authority as outlined above, is established, staffed, and effectively operational.

RECOMMENDATION II

CONTROL OF EMISSIONS OF SULFUR DIOXIDE FROM EXISTING POWER GENERATION PLANTS

It is found:

a) That in order to protect health and welfare of residents in the bi-State metropolitan area, the New York State Ambient Air Quality Objectives already adopted for the New York State portion of the area should be applied over the entire area. These standards provide that a 24-hour average concentration of sulfur dioxide shall not exceed 0.1 ppm by volume more than 1% of the time and shall not exceed 0.25 ppm by volume on an hourly basis more than 1% of the time.

b) That these levels are consistently exceeded in a considerable portion of the area.

c) That the evidence in the record shows that nearly 40% of the annual emissions of this toxic, corrosive gas into the atmosphere of the 17-county area emanates from steam and electric-power generating plants.

Therefore, as an immediate measure to be taken, it is recommended:

That all steam and electric power generating facilities producing steam or electric power for sale currently existing within the 17-county, bi-State area not be permitted to burn fuel containing in excess of 1.0% sulfur by weight beyond October 1, 1969, unless they have installed effective means to control sulfur oxide emissions (calculated as sulfur dioxide) to an equivalent level. Local programs can, and should be encouraged, to meet the above target prior to the deadline recommended.

RECOMMENDATION III

CONTROL OF EMISSIONS OF SULFUR DIOXIDE FROM NEW OR EXPANDED EXISTING POWER GENERATION PLANTS

It is found:

a) That present electric generating capacities for the area must be increased; and

b) That it must be ensured that meeting these increased demands for electricity does not impose an additional burden on the health and welfare of the bi-State community.

It is therefore recommended that:

After July 1, 1967, no new power generating facilities or expansion (or major reconstruction) of existing facilities be allowed within the 17-county, bi-State area of New York and New Jersey, unless evidence is presented guaranteeing an assured 20-year supply of low-sulfur fuel which would not allow emissions at any time to exceed 0.35 pound of sulfur dioxide per million Btu gross heat input, or unless it can be shown that demonstrated effective means will be employed to control sulfur oxide emissions to an equivalent level.

RECOMMENDATION IV
CONTROL OF EMISSIONS OF SULFUR DIOXIDE FROM SPACE HEATING

It is found :

a) That the use of sulfur-rich fuels for space heating and other domestic or commercial uses is responsible for more than 50 percent of annual emissions of this contaminant; and

b) That not only do these emissions sharply increase in the winter months, but they are released relatively close to ground level where people live and work.

It is therefore recommended that:

1) Fuel utilized for space heating or for other domestic, commercial and industrial uses within the 17-county bi-State area after October 1, 1969, shall be natural gas, coal containing not in excess of 0.2 percent sulfur by weight or oil containing not in excess of 0.3 percent sulfur by weight.

2) Local, State, and Federal agencies be strongly urged to comply with this standard at an even earlier date, to demonstrate their desire to provide guidance to private sectors of the community.

RECOMMENDATION V
CONTROL OF EMISSIONS OF SULFUR COMPOUNDS FROM INDUSTRIAL PROCESSES

It is found:

That specific point source emissions of sulfur oxides and extremely malodorous sulfur compounds (mercaptans, hydrogen sulfide, etc.) result in localized excessive ground-level concentrations that cause detriment to the health and welfare of the community.

It is therefore recommended that:

1) Standards be established which would limit emissions of sulfur dioxide to 2000 ppm at existing sources and 500 ppm at new sources. Dilution or diffusion of exhaust gases shall not be considered an acceptable means of meeting this standard (sulfur recovery plants are to be exempted).

2) All sources emitting odorous or offensive sulfur compounds shall be controlled to the extent that no nuisances are created, and legal enforcement and inspection programs be rigorously prosecuted so as to assure good operating practices to the end of minimizing accidental or inadvertant releases of such compounds.

3) As agreed by the Conference participants, the State of New Jersey, when applying Chapter VIII of its Air Pollution Control Code, which becomes effective March 1, 1967, shall assign first priority to the nine New Jersey counties in the 17-county interstate metropolitan area, and that the State of New Jersey will submit to the Presiding Officer, no later than June 1, 1967, a progress report delineating the steps taken in this regard.

RECOMMENDATION VI
CONTROL OF CARBON MONOXIDE EMISSIONS

It is found that:

a) Evidence is inadequate to establish interstate transport of carbon monoxide,but concentrations in localized areas approach limits specified in recognized air quality standards.

b) Available air quality data do not adequately identify the maximum levels and frequencies to which many persons are exposed.

c) Ninety-five percent of the carbon monoxide is emitted from motor vehicles operating throughout the 17-county area.

d) There are only two significant process sources of carbon monoxide in the metropolitan area -- Hess Oil Company and California Oil Company in Sewaren and Perth Amboy, New Jersey respectively. Hess Oil Company emits 79,000 tons and the California Oil Company emits 75,000 tons of carbon monoxide annually. Using accepted diffusion equations, it is computed that maximum short-term groundlevel concentrations from these plants under varying meteorological conditions will range from 6.0 ppm carbon monoxide, 8 kilometers from the source, to 167 ppm carbon monoxide, 4/10 kilometers from the source.

e) Federal and State regulations will require exhaust controls on all new 1968 model-year and later automobiles and light trucks, with an anticipated reduction in carbon monoxide emissions.

f) The State of New Jersey already has adopted legislation and is implementing a control program for reducing atmospheric carbon monoxide levels.

g) It is technologically feasible to reduce carbon monoxide emissions from used motor vehicles, and it is possible to develop and implement other actions that would reduce emissions in presently congested areas.

It is therefore recommended that:

1) The States continue to monitor atmospheric levels of carbon monoxide, particularly in locations where maximal levels are expected to occur, and that they advise the Secretary of Health, Education, and Welfare of any apparent need for more stringent control of new motor vehicle emissions.

2) Individual jurisdictions should continue to give consideration to the necessity and means for reducing atmospheric carbon monoxide levels.

3) That, as suggested by the Conference participants, the State of New Jersey urge Hess Oil Company and California Oil Company to control their contributions to localized carbon monoxide levels. In accordance with good engineering practice, waste heat boilers can be installed economically to serve this purpose.

RECOMMENDATION VII
CONTROL OF EMISSIONS FROM THE ABEX CORPORATION - MAHWAH, NEW JERSEY

It is found that:

Emissions from the Abex Corporation in Mahwah, New Jersey, are transported from the State of New Jersey into the State of New York and cause air pollution problems consisting of odors and impaired visibility and of objectionable levels of particulate matter in the vicinity of Suffen, New York. Cognizance is taken of the remedial measures being undertaken by the Corporation, which are expected to meet the air pollution control requirements of the State of New Jersey by August 1, 1967. There is no assurance that the proposed installation will adequately reduce emissions from the plant so as not to cause or contribute to air pollution which endangers the health and welfare of persons in the State of New York.

It is therefore recommended that:

1) The time schedule for the abatement of emissions agreed to between the Abex Corporation and the State of New Jersey be adhered to strictly.

2) The States of New Jersey and New York mutually arrange to undertake surveillance of the operation and effectiveness of the controlled process, after it is installed for a period of at least 60 days, and report in writing to the Presiding Officer of the Conference (or the Chairman of the continuing session) the results of such surveillance within 75 days for such further consideration and action, if any, as may be necessary.

APPENDIX B. AEROMETRY OPERATIONS AND TECHNIQUES

Introduction

Phase I of the New York - New Jersey Air Pollution Abatement Activity included a technical investigation of air pollution in the New York - New Jersey metropolitan area, which was conducted during the summer of 1966. The air quality survey of this investigation included measurements of sulfur compounds and carbon monoxide. The results of this study are reported in the technical report titled, "New York - New Jersey Air Pollution Abatement Activity -- Sulfur Compounds and Carbon Monoxide," dated January, 1967.

The second phase of the Air Pollution Abatement Activity was primarily concerned with suspended particulate matter. The air monitoring network associated with this phase of the study will be described and discussed under appropriate headings.

Suspended Particulate - High-Volume Samplers

The principal sampling apparatus used during Phase II was the General Metals Works Model 2000 H High-Volume particulate sampler.* The sampler consists of a specially housed vacuum sweeper motor, which is attached to a filter holder or adapter. The adapter is rectangular shaped (8 by 10 inches) and consists of two parts, a cone shaped stainless steel filter support screen and an open rectangular face plate of cast iron with a sponge-rubber gasket.

In sampling, a filter is placed between the filter-support screen and the gasket face plate and screwed onto the blower unit to make an airtight seal. The air drawn through the filter is measured continuously by a recording transducer. Particulate matter from the ambient air is collected for 24-hour periods. For the purpose of this study, a timer-controlled switching system was used, permitting operation 2 out of every 3 days using two 2000 H samplers, and requiring a site visit only 1 out of every 3 days.

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*G.A. Jutze and K.E. Foster, Recommended standard method for atmospheric sampling of fine particulate by filter media - High-Volume Sampler TR-2 - Air Pollution Measurements Committee. J. Air Poll. Cont. Assoc., Volume 17, No. 1. (Jan. 1967).

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A network consisting of 18 particulate stations using Hi-Volume samplers was oriented along the 225°-45° axis passing through the Bayonne, New Jersey, monitoring station. Ten of the stations are located at the air monitoring sites used in Phase I. Eight additional stations were selected in highly polluted areas close to interstate boundaries. The orientation of the stations was planned to demonstrate transport of interstate pollution as well as to provide continuity with data from Phase I. The 18 particulate sampling stations, including site address and location, are tabulated in Table B-1. The locations are shown in Figure B-1.

Total suspended particulate data were collected by 8-by-10-inch glass fiber filters over 24-hour periods. Results were based on differences between the initial and final weights of each filter and volume of air sampled. Data are reported as micrograms of total particulate per cubic meter of air.

Sulfates were determined by the turbimetric method. A portion of the filter was soaked and rinsed with distilled water. Sulfa Ver Powder (Sulfa Ver Powder: Cat. No. 396 Hack Chemical Co., Ames, Iowa) was added, and absorbance was read at a wavelength of 450 microns. Sulfate concentrations were determined from a calibration curve plotted to show standard sulfate concentrations against absorbance. Results are reported as micrograms of $SO_4^=$ per cubic meter of air.

Acid content was determined by placing a portion of the exposed filter in a solution containing a known quantity of dilute sodium hydroxide and titrating to a pH of 7. Total acidity was determined and acid content was reported as H_2SO_4.

Suspended Particulate - AISI Samplers

Seven AISI smoke shade samplers are operating in the New York - New Jersey air pollution study area. Analyzers are located at New York University, Central Park, 170 E. 121st Street, and New Rochelle in New York State and at Bayonne, Newark, and Ancora in New Jersey. Locations are listed in Table B-1 and shown in Figure B-2.

The instruments sample the air continuously with an integration period of 2 hours with the exceptions of Bayonne (No. 006) and Newark (No. 007), where the period was hourly. The sample tapes are collected and sample spots are read for percent transmission. Levels of contamination are reported as coefficient of haze (Cohs) per 1000 lineal feet of air.

Settleable Particulate - Dustfall

Dustfall consists of relatively heavy particles that settle out close to their sources. These values indicate the degree of nuisance that may be expected from dirty window sills, venetian blinds, balconies, etc. Dustfall is collected in plastic buckets or glass jars. The contents of the buckets are rinsed with distilled water and transferred to preweighed beakers. The beakers are placed in a drying oven held at 110° C. The weight of the dry solids is determined, and results are reported in tons per square mile per month. The location of the dustfall network is shown in Table B-1 and Figure B-3.

Respirable Dust Samplers

The instrument used for measuring the respirable dust fraction was a stainless steel Aerotec sanitary cyclone assembly. Air is drawn through it at a rate of 40 cfm by means of a typical high-volume blower motor. The particles are separated in the cyclone assembly according to size. The larger particles (approximately 3.5 to 100 microns) are deposited in a quart glass jar, which is attached to the bottom of the cyclone. The smaller particles (with a median diameter of 3.5 microns) exhaust through the outlet of the cyclone and are drawn through the inverted glass fiber tube. These fine particles are than deposited on a glass fiber filter, 8 by 10 inches, inserted into the expanded section of the sampler. The respirable particulates are determined by weight and are reported in micrograms per cubic meter of air. Locations of the sampling sites are given in Table B-1 and Figure B-2.

Table B-1 - LOCATION OF PARTICULATE SAMPLING STATIONS

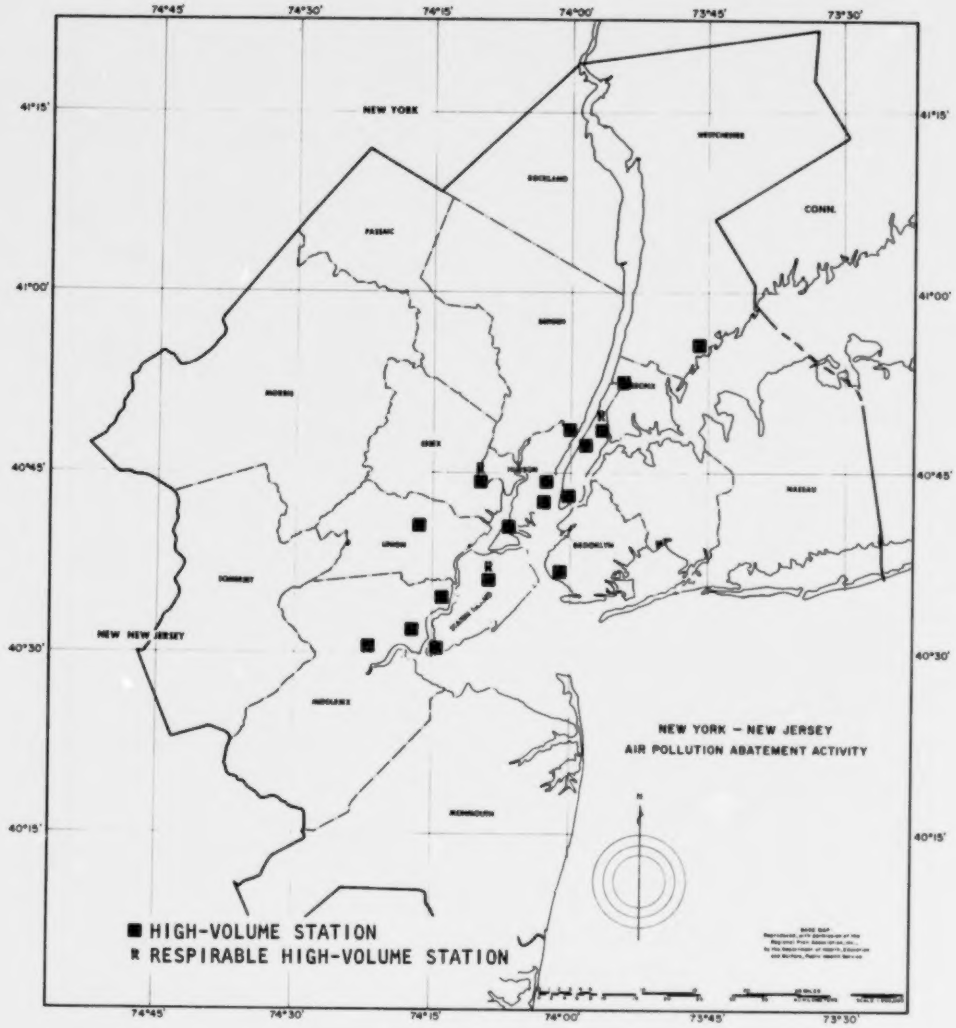
Station number	Agency	Address	Sampler			
			Hi-Vol	AISI	Dustfall	Respirable
001	USPHS	Willowbrook State School 2760 Victory Blvd. Staten Island, N.Y.	x			x
002	USPHS	Roselle Municipal Parking Lot Chestnut & E. First St. Roselle Park, N.J.	x		x	
003	USPHS	Fair Ridge Shopping Center Bergen Ave. & Fairview St. Fairview, N.J.	x		x	
004	USPHS	Fort Hamilton Army Chaplain School Brooklyn, N.Y.	x			
005	USPHS	Raritan Depot Metuchen, N.J.	x		x	
006	NJS	Bayonne Hudson Park Bayonne, N.J.	x	x	x	
007	NJS	Newark Raymond Blvd.& McCarter Hwy. Newark, N.J.	x	x	x	x
012	USPHS NYC	N.Y. University 1911 Osborne Place Bronx, N.Y.	x	x		
013	NYC	Central Park Belvedere Tower Manhattan, N.Y.		x	x	
014	NYC	Bureau of Laboratories 170 E. 121st St. Manhattan, N.Y.	x	x		x
016	NYS	New Rochelle 30 Church Street New Rochelle, N.Y.	x	x		
021	NJS	Ancora N.J. State Hospital Hammonton, N.J.	x	x	x	
022	NYC	Samuel Gomper H.S. 445 Southern Blvd. Bronx, N.Y.			x	

Station number	Agency	Address	Sampler			
			Hi-Vol	AISI	Dustfall	Respirable
024	NYC	Shearton-Whitehall Bldg. 17 Battery Place Manhattan, N.Y.	x			
025	NYC	57th St. & 10th Ave. CBS Manhattan, N.Y.	x			
026	NYC	Firehouse 10-42 47th Ave. Queens, N.Y.			x	
028	NYC	Willowbrook State School 2760 Victory Blvd. Staten Island, N.Y.			x	
033	NYC	Junior High School #143 515 W. 182 St.& Amsterdam Av. New York			x	
034	NYC	Christopher Columbus H.S. Waring & Bronxwood Ave. New York			x	
035	NYC	Public School #72 Logan & Edison St. Bronx, N.Y.			x	
037	NYC	Queensboro Hall-Union Turnpike & Queens Blvd. Kew Gardens, Queens			x	
039	NYC	JFK International Airport NYC Building 141 Port Authority of New York			x	
040	NYC	NYC Dept. of Health 67th & Rockaway Blvd.(Beach) Queens			x	
045	USPHS	S.Boyes Rug Clean. Co. Victory Bridge Plaza So. Amboy, N.J.			x	
051	USPHS	Gary's Highway Citgo Rt. 22 & Myrtle Ave. Scotch Plains, N.J.			x	
057	USPHS	Central East Hanover School 400 Ridgedale Ave. East Hanover, N.J.			x	
064	USPHS	Joyce Food Products Boumar Place East Paterson, N.J.			x	

Station number	Agency	Address	Sampler			
			Hi-Vol	AISI	Dustfall	Respirable
093	USPHS	Power Industrial Prod. Co. Rt. 3 at Meadow Road Rutherford, N.J.			x	
095	USPHS	Fire Station 294 Central Ave. Union City, N.J.	x		x	
098	USPHS	WMCA Trans Station Bellville Turnpike Kearny, N.J.			x	
100	USPHS	Bus Lomelo Service Station So. Center St. & Reock St. Orange, N.J.			x	
101	USPHS	Consolidated Fire House 7th St. & Newark Ave. Jersey City, N.J.	x		x	
104	USPHS	Matlack, Inc. 171 Front St. Elizabeth, N.J.			x	
107	USPHS	Water Pumping Station Westfield & Fowler Ave. Rahway, N.J.			x	
108	USPHS	Carteret Sewage Treatment Plant 339 Roosevelt Ave. Carteret, N.J.	x		x	
109	USPHS	Woodbridge Sewage Trtmt. Plt. Cliff Road Sewaren, N.J.			x	
113	USPHS	Ralph Toto 930 Old Bridge Turnpike Old Bridge, N.J.			x	
116	USPHS	Bayside High School 32nd Ave. - 208th St. Queens, N.Y.			x	
118	NYC	Main Post Office 380 W. 33rd St. Manhattan, N.Y.			x	
119	NYC	P.S. #13 5501 94th St. at 55 Ave. Queens, N.Y.			x	
120	NYC	Andrew Jackson H.S. 207-01 116th Ave. at 207 St. Queens, N.Y.			x	

Station number	Agency	Address	Sampler			
			Hi-Vol	AISI	Dustfall	Respirable
121	NYC	New York City Department of Health Red Hook Center 250 Baltic St. Brooklyn, N.Y.			x	
122	NYC	Mt. Prospect Lab DWSG & E 353 Park Place Brooklyn, N.Y.			x	
123	NYC	Thomas Jefferson H.S. Pennsylvania & DuMont Ave. Brooklyn, N.Y.			x	
124	NYC	Brooklyn College Bedford Ave. & Ave. H Brooklyn, N.Y.			x	
125	NYC	Sheepshead Bay 3000 Ave. X at Nostrand Ave. Brooklyn, N.Y.			x	
128	NYC	Great Kills Branch Library 56 Giffords Lane Staten Island, N.Y.			x	
130	USPHS NYC	Engine Company #151 7219 Amboy Road Tottenville, Staten Island	x		x	
132	USPHS	Perth Amboy Fire Station Engine #6 Rt. 440 & Traffic Circle Perth Amboy, N.J.	x			
140	NYC	P-S 7 Kingsbridge Drive & W. 232 St. Bronx, N.Y.			x	
141	NYC	Bronx J.H.S. 142 3750 Baychester Ave. Bronx, N.Y.			x	
142	NYC	Dept. of Health Center 151 Maujer St. Brooklyn, N.Y.			x	
143	NYC	New Utrecht High School 1601 80th St. Brooklyn, N.Y.			x	
144	NYC	P.S. 7 160 E. 120th St. Manhattan, N.Y.			x	
145	NYC	Merchant's Carpet Company 32 East Broadway Manhattan, N.Y.			x	

Station number	Agency	Address	Sampler			
			Hi-Vol	AISI	Dustfall	Respirable
147	NYC	Department Welfare 95 Central Avenue St. George, Staten Island			x	
148	NYC	P.D.N.Y. 112 Pct. 2275 Hylan Blvd. Dongan Hills, Staten Island			x	
149	NYC	Landfill #1 Dept. of Sanitation Muldoon Ave. off Fresh Kill Rd. Staten Island			x	
		Totals	18	7	50	3



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CONN.
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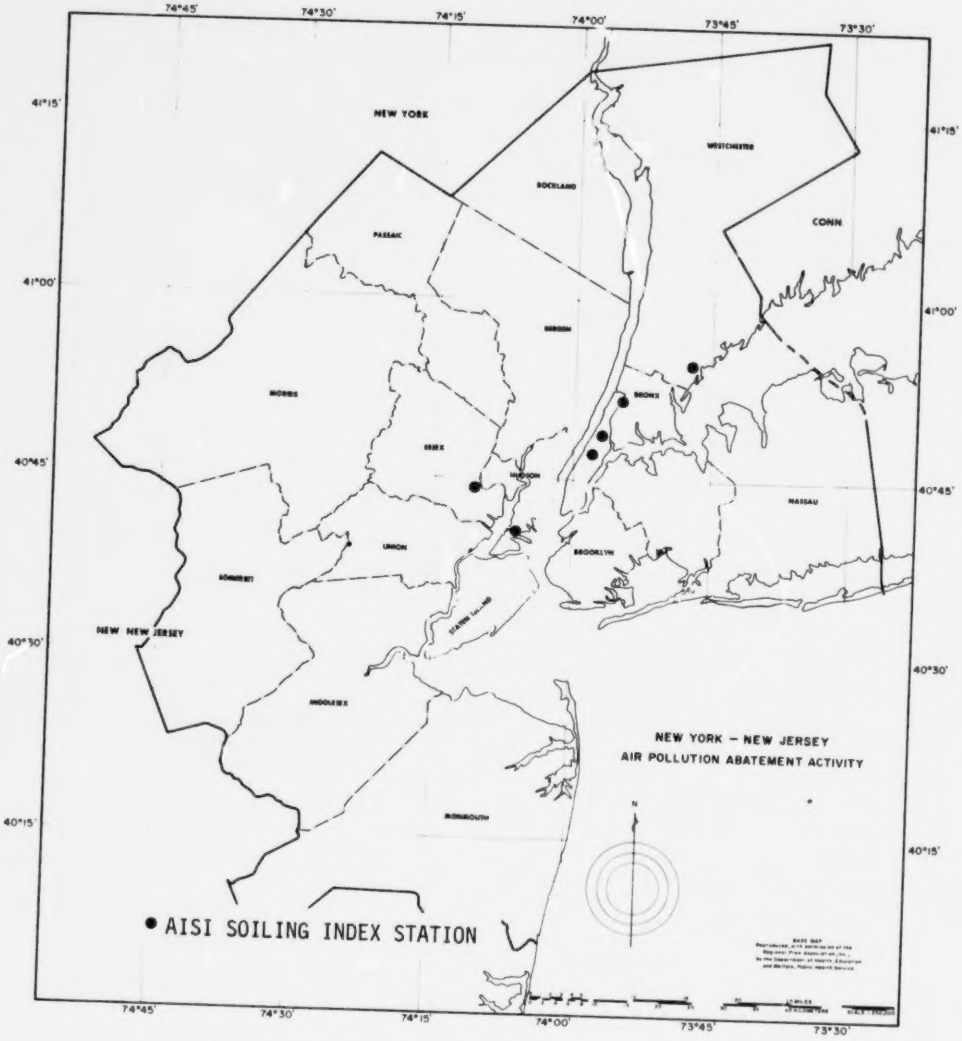
BERGEN
MORRIS
ESSEX
BRONX
HUDSON
NASSAU
UNION
BROOKLYN
SOMERSET
STATEN ISLAND
NEW NEW JERSEY
MIDDLESEX
MONMOUTH
R
N
NEW YORK – NEW JERSEY
AIR POLLUTION ABATEMENT ACTIVITY
■ HIGH-VOLUME STATION
R RESPIRABLE HIGH-VOLUME STATION

Figure B-1. Particulate sampling stations.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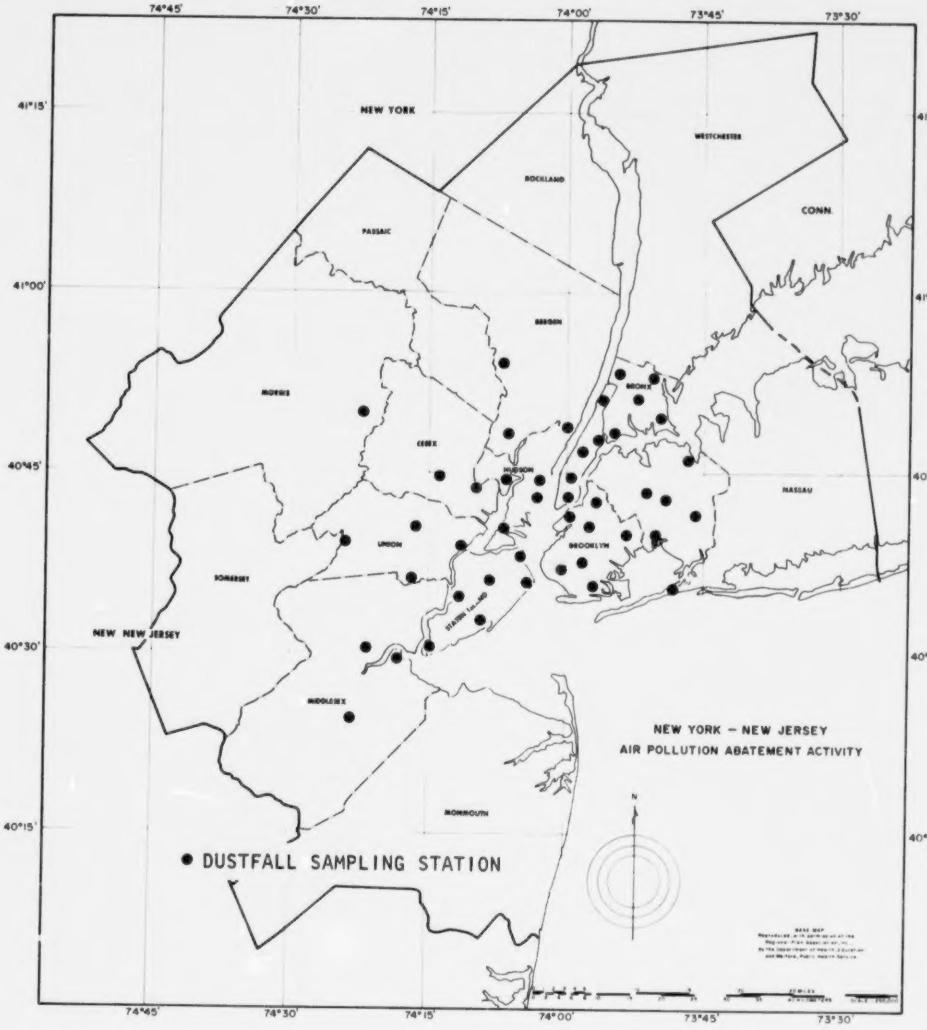
SOMERSET
STATEN ISLAND
NEW NEW JERSEY
MIDDLESEX
MONMOUTH
NEW YORK – NEW JERSEY
AIR POLLUTION ABATEMENT ACTIVITY
N
● AISI SOILING INDEX STATION
SCALE 1:500,000

BASE MAP
Reproduced, with permission of the
Regional Plan Association, Inc.,
by the Department of Health, Education
and Welfare, Public Health Service

Figure B-2. Soiling index (AISI) stations.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NASSAU
UNION
BROOKLYN
SOMERSET
STATEN ISLAND
NEW JERSEY
MIDDLESEX
MONMOUTH
NEW YORK — NEW JERSEY
AIR POLLUTION ABATEMENT ACTIVITY
N
● DUSTFALL SAMPLING STATION
BASE MAP

Figure B-3. Dustfall sampling stations.

APPENDIX C. EMISSIONS INVENTORY PROCEDURE

Several methods were used to estimate the magnitude of particulate air contaminants from sources in the study area. Where the pollution potential was great, efforts were made to obtain exact data either by direct interview or by mail survey. For the many small sources - automobiles, trucks, medium-to-small residences, and small commercial, governmental, and industrial establishments - direct interview or mail survey was not possible. For these background sources, fuel usage, refuse incineration, and resultant particulate emissions were determined in each area by the most accurate means available. Area fuel usage by the multitudinous small sources were updated from 1965 using estimated overall area changes and the relative distributions of Phase I.*

Inventory data were compiled from February through October 1967. The New Jersey program was operated out of the Raritan Arsenal by personnel of the Public Health Service and the New Jersey State Department of Health. The New York program was conducted out of the Public Health Service offices at 42 Broadway, New York City. Survey work was also conducted from the headquarters of the New York City Department of Air Pollution Control and the Health Departments of Nassau, Rockland, and Westchester County as well as field offices of the New York State Health Department.

Particulate air contaminants in the study area arise from the burning of mobile and stationary combustion fuels, from refuse incineration and open burning, and from industrial processes. The emissions inventory consisted of evaluating the use of each fuel and determining emissions from refuse burning and process industries.

Emissions were determined directly from fuel input to the equipment for both mobile and stationary sources. Emission factors for each fuel and for each type of incinerator are shown in Table C-1. These factors were used wherever more specific information was not available. Annual consumption of all fuels, process emissions, and incineration emissions were determined for each zone in the study area. Emission densities, in tons per square mile, were calculated for each zone for an average calendar day. Emissions by county and source category in tons per day and by county in tons per day per square mile were also calculated for minimum, average, and maximum space-heating days.

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*New York - New Jersey Air Pollution Abatement Activity, Sulfur Compounds and Carbon Monoxide, U.S. Department of HEW, PHS, Cincinnati, Ohio, January 1967.

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Point Sources

Each industrial site, commercial establishment, municipal incinerator, governmental building, etc., from which 100 tons or more of particulate matter was emitted in 1966 was considered a point source. All point sources were evaluated by interview or mail survey.

Gasoline and Diesel Fuel Usage

Motor vehicle fuel consumption was determined by coupling available traffic study data with county fuel consumption. As in Phase I, information compiled by the Tri-State Transportation Commission was used to determine the relative quantities of vehicular fuels burned in each zone. In New Jersey statewide service station sales in 1966 were obtained from the State Department of the Treasury. This figure was used to update county fuel totals from 1965 to 1966. No comparable information was available for 1966 in New York. Nevertheless, the State Department of Commerce had estimated gasoline sales for each county in Calendar Year 1965.

For New York City, the State estimates for all five boroughs were totaled, and the resultant total apportioned to each zone according to traffic study data. Although gasoline consumption in the four heavily populated boroughs of New York City changed little from 1965 to 1966, some increases probably occurred in Richmond, Nassau, Rockland, and Westchester County. As in the Phase I inventory, diesel-powered vehicles were assumed to account for 3 percent of the vehicle-miles.

Process Sources

Emissions from industrial processes were obtained from plant inspections, mail surveys, and telephone inquiries. Some industries had stack test results available. Most of the estimates furnished by industry officials were consistent with emission factors used by the Public Health Service.[*][†] When particulate emission estimates of company officials appeared inconsistent with the size and type of industry and could not be substantiated, adjustments were made by Public Health Service engineers.

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[*] M. Mayer, A Compilation of Air Pollution Emission Factors for Combustion Processes, Gasoline Evaporation, and Selected Industrial Processes, U. S. Public Health Service, Division of Air Pollution Control, May 1965.

[†] R.L. Duprey, Particulate Emission and Size Distribution, (unpublished) National Center for Air Pollution Control, May 1967.

Combustion Fuels

Sources were defined in terms of fuel and source type, the latter principally to determine variations due to space-heating. Anthracite and bituminous coals, distillate and residual oils, and natural gas are the only fuels used in significant quantities in the study area. Fuel sources were listed as residential, commercial and governmental, power plant, and industrial. Residential sources include all dwellings, from single family homes to high-rise apartment buildings.

The portion of fuel burned for space-heating and that burned on a steady day-to-day basis throughout the year were determined. It was reasoned that all commercial and governmental fuel, much residential fuel, and some industrial fuel was burned for space-heating purposes.

At power plants, fuel is burned at a reasonably constant daily rate throughout the year. The variable use of fuel for space-heating determines the differences in emissions on minimum, average, and maximum space-heating days.

Point Sources From Fuel Use

To be in the point-source category (100 tons per year or more) requires the burning of 16,500,000 gallons of residual oil or upwards of 4000 tons of coal depending on the method of firing and collection equipment.

Combustion Fuel Use In New Jersey

Total 1966 anthracite and bituminous coal usage figures were available for the state of New Jersey.[†] Bituminous coal was apportioned to the nine New Jersey counties in the study area according to the fractions of industrial and commercial employees. Anthracite coal was apportioned to the nine counties on a population basis. Of coal allocated to the nine-county area, 73 percent of the bituminous and 47 percent of the anthracite were accounted for by the survey and interview of commercial, governmental, and industrial installations. The same general distribution between small industrial, residential, commercial and governmental sources was used as in the Phase I study to account for the other portions of anthracite and bituminous coals. Most of the anthracite not accounted for by the survey was assumed to be burned for residential space-heating.

[†] U.S. Department of Interior, Bituminous and Lignite Distribution Reports, 1966.

Total residual oil usage was updated and distributed in proportion to Phase I allocations. No changes from Phase I were made in distillate (No. 1 through 4) oil.

Natural gas figures were obtained from the gas distributors in the nine-county area. Sales data were divided between industrial, residential and commercial, and governmental users by the gas companies. Gas was distributed to zones by Phase I methods and proportions.

Residential Fuel Use In New Jersey

County totals for each of the five major fuels were determined by the methods outlined above. These totals were then compared with respective Phase I totals. Each zone received the same relative amount of the New Jersey area fuel as in Phase I.

Industrial Fuel Use In New Jersey

Much of the industrial fuel was sampled directly, particularly coal. Industrial fuel totals were determined by county, and the total of each surveyed fuel was subtracted from these county totals. The remaining fuel was apportioned between the zones in the same pattern used in the Phase I study.

Commercial And Governmental Fuel Use In New Jersey

Large commercial and governmental fuel users were surveyed during the Phase I study. These large users were contacted by telephone or mail survey during Phase II to update their usages to 1966. Surveyed fuel totals were subtracted from the total allocated to the particular county. Background fuel use was allocated to individual zones using the Phase I distribution.

Combustion Fuel Use In Outer New York Counties

In Nassau, Rockland, and Westchester County fuel usages were updated to 1966 using a combination of population changes, natural gas consumption (from distributing utilities), surveys of coal dealers, and direct information from major sources. Heat requirements increased in proportion to population. Natural gas was determined to fill part of the needs created by increased population and by cutbacks in coal burning. The remaining heat requirement was assumed to be filled by fuel oils.

Combustion Fuel Use In New York City

Except for large sources, Phase I data were used for all fuels except natural gas. Natural gas figures were available by borough for Calendar Year 1966 from the distributors. Borough figures were compared with Phase I totals and fuels distributed to zones in the same proportions used in the Phase I study.

Steam-Powered Electric-Generating Power Plants

Fuel-use figures were obtained directly from steam and steam-electric utilities. Amounts of residual oil, bituminous (in one case anthracite) coal, and natural gas used at all power-generating stations were provided along with coal ash contents and rated collection efficiencies of particulate collection equipment. The average collection efficiencies of the control devices were assumed to be somewhat lower than their rated efficiencies, based on estimates by Public Health Service personnel. Particulates vented to the collectors were determined from Mayer.* Collectors were assumed to be effective only during coal firing.

Ships In Harbor

Since much of the harbor lies between New York and New Jersey, emissions from operations in these waters were not attributed to either state, but to the Harbor Area. Total ship-trip types and amounts of each fuel per trip were made available by all major shipping lines. Particulate emissions were calculated by Public Health Service personnel.

Aircraft Emissions

The number and types of aircraft operations at LaGuardia, Kennedy, and Newark Airport were obtained from the Air Traffic Division of the Federal Aviation Agency for 1966. Particulate emissions were apportioned to the zones in which the runways are located. Emissions were assumed to be concentrated at the airport runways and were calculated as "operations under 3500 feet" from emission factors of Mayer* and Hochheiser†.

Refuse Incineration

Somewhat different methods were used to estimate the quantities of refuse burned in New York and New Jersey. In most instances, test data were not available and emission factors had to be estimated.

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*op. cit., p. 138.

†S. Hochheiser, et al., Emissions from Jet Aircraft, Paper No. 67-126 presented at the Air Pollution Control Associations Meeting, Cleveland, Ohio, June 1967.

Industrial On-Site Incineration

Information on refuse disposal was obtained directly by interview or mail survey for all portions of the study area.

Municipal Incineration

Refuse tonnages burned were obtained for all municipal incinerators. Particulate emissions were based on stack tests for most New York City incinerators. Such data were not available for the majority of municipal incinerators in New Jersey and the outer New York counties. In the latter cases, estimates were made by Public Health Service personnel.

Other On-Site Incineration In New Jersey

Although most New Jersey refuse is trucked to sanitary landfills, little information is available as to the approximately 12 percent that is burned. A mail survey was conducted of all local health officers in the nine counties. From the return of 50 percent of the questionnaires, a relationship was developed between on-site incineration, backyard burning, and population density. In areas of highest population density a larger fraction of combustible refuse is incinerated and less is buried at landfills. This relationship was used by Public Health Service personnel to estimate non-industrial on-site incineration except where accurate data were available. For all residential incineration in the study area, it was assumed that 1.22 tons of refuse per dwelling unit are burned annually. All residential incinerators were assumed to be of flue-fed design with emission factors of 26 pounds per ton of refuse.

On-Site Incineration In New York City

A total city on-site refuse figure was made available by New York City personnel, but there was no separation by zone or borough. It was reasoned that essentially all on-site burning was conducted in about 11,000 flue-fed incinerators located in the larger apartment houses. These larger buildings also usually burn residual fuel oil for space heating. Refuse generated at smaller apartments and commercial, governmental, and industrial establishments was assumed to be collected by the Department of Sanitation. On-site refuse incineration in each New York City zone was therefore, assumed to be in proportion to the use of residual fuel oil by residential sources. As previously noted, all residential incinerators were assumed to be of single-chamber, flue-fed design.

Other On-Site Incineration In Nassau County

An intensive survey of apartment houses in Freeport, Hempstead, and Lynbrook had been made by the Nassau County Health Department. These data were used to develop a relationship between apartment size and method of refuse disposal. Information as to the location and size of apartment buildings in other portions of the county was provided by a report* of the Nassau County Planning Commission. The information was combined to project residential refuse burning to the remaining areas of the county. Commercial and governmental refuse burning were estimated from relationships developed in New Jersey.

Other On-Site Incineration In Rockland County

Specific survey information was obtained as to the location and size of all on-site incinerators in Rockland County.

Other On-Site Incineration In Westchester County

For the more populated areas of the county - Eastchester, Greenburgh, Mount Vernon, New Rochelle, Scarsdale, White Plains, and Yonkers - survey information was obtained as to on-site incineration at residential, commercial, and governmental sources. In the less populated areas of Westchester County, the New Jersey relationships were used as a basis for estimates.

Open Burning In The Harbor

Combustible refuse is burned on barges in New York Harbor by the U.S. Army Corps of Engineers and by private disposal firms. The refuse consists of wooden pilings and miscellaneous debris. One private firm and the Corps of Engineers supplied information as to the refuse burned. Emissions were assumed to be 20 pounds of particulate per ton of refuse.

Daily Variations In Particulate Emissions

Particulate emissions were determined on a county basis for minimum, average, and maximum space-heating days in 1966. For each county, particulate emissions were divided into a variable fraction resulting from operations that are essentially constant throughout the year. Variable particulate emissions were assumed to consist of:

1. All commercial and governmental emissions.

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*Nassau County Planning Commission, Apartments, Their Past and Future Impact on Suburban Living Patterns, December 1963.

2. A portion of the industrial fuel emissions, 50 percent in New York City and 23 percent for all other areas.
3. A portion of the residential emissions, (Table C-2 for County factor).

Residential space-heating factors as listed in Table C-2 were estimated from the relative amounts of the various fuels used for space-heating and non-space-heating purposes. All coal and fractions of each other fuel were assumed to be used for space-heating purposes.

Steady day-to-day particulate emissions were considered to consist of:

1. All process emissions.
2. All power plant emissions.
3. A portion of all industrial emissions, 50 percent in New York City and 77 percent in all other areas.
4. A portion of the residential emissions (Table C-2 for County factor).
5. All refuse combustion emissions.
6. All vehicular emissions.
7. All aircraft and shipping emissions.

On a minimum heating day, it was assumed that there was no space heating; therefore, emissions are represented by the above-mentioned steady particulate total.

Average and maximum heating-day totals were determined by adding steady emissions to variable emissions during respective days. Meteorological data acquired from the U.S. Weather Bureau were used to determine the fractions of the yearly variable particulate emitted during average and maximum heating days. The following formulas were used to calculate daily particulate emissions:

$$\text{Minimum day} = \text{Steady particulate, tons per day}$$
$$\text{Average day} = \text{Minimum day} + (\text{Variable Particulate, tons/year})\left(\frac{21}{5070}\right)$$
$$\text{Maximum day} = \text{Minimum day} + (\text{Variable Particulate, tons/year})\left(\frac{48}{5070}\right)$$

The factor 21/5070 represents the fraction of annual degree-days occurring on the average heating day. The value 21 is the mean degree-days for all days of the year with average temperature less than 65°F. The value 5070 is the cumulative degree-days for year 1966. The factor 48/5070 represents the fraction of annual degree-days occurring on one of the coldest days; the value 48 is the normalized average degree-days for the 4 coldest days of the year. Daily tonnages were devided by the county areas to yield emission concentrations in terms of tons of particulate per square mile.

Particles Size Distribution

Particulate emissions were divided into three size classifications; less than 5 microns, between 5 and 44 microns, and greater than 44 microns. Particle size distribution by percent was determined for each county using Public Health Service information.[*][†] Particle size distribution factors for source and fuel type are tabulated in Table C-3.

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[*] op. cit., p. 138.

[†] op. cit., p. 138.

Table C-1. PARTICULATE EMISSION FACTORS FOR SMALL AND INTERMEDIATE SIZE SOURCES

	Particulate emission factor
Anthracite and bituminous coal (industrial) uncontrolled	50 lb/ton
Anthracite and bituminous coal (all other)	35 lb/ton
Residual oil	12 lb/1000 gal.
Distillate oil	11.1 lb/1000 gal.
Natural gas	19 lb/MMCF
Diesel fuel	110 lb/1000 gal.
Gasoline	11 lb/1000 gal.
Flue-fed incinerators	26 lb/ton
Other single-chamber incinerators	25 lb/ton
Multiple-chamber incinerators	4-5 lb/ton
Backyard burning	20 lb/ton

Table C-2. RESIDENTIAL SPACE HEATING FACTORS

County	Particulate emissions from space heating, % of residential	Particulate emissions from water heating, cooking, etc., % of residential
New Jersey		
Bergen	90	10
Essex	91	9
Hudson	93	7
Middlesex	92	8
Monmouth	92	8
Morris	91	9
Passaic	92	8
Somerset	90	10
Union	91	9
New York		
Bronx	87	13
Brooklyn	86	14
Staten Island	83	17
Manhattan	69	31
Queens	83	17
Nassau	86	14
Rockland	78	22
Westchester	85	15

Table C-3. PARTICLE SIZE DISTRIBUTION ASSUMPTIONS

Particulate matter pollution source	Fraction in size range, %		
	>44μ	<44μ> 5μ	<5μ
Distillate oil	0	50	50
Residual oil			
Power plant	0	0	100
All other	0	50	50
Anthracite and bituminous coals			
Power plant (controlled)	0	0	100
Residential	35	14	51
NYC commercial and governmental	35	14	51
All industrial	70	28	2
NYS and NJ commercial and governmental	70	28	2
Natural gas	0	0	100
Process emissions	5	10	85
Refuse combustion	40	45	15
Automobile (gasoline)	0	0	100
Automotive (diesel)	0	37.5	62.5
Aircraft and shipping	0	0	100

APPENDIX D. POLLUTANT MEASUREMENT DATA

This appendix contains tables and figures pertinent to the Technical Report. Included are the following:

1. Emission densities of particulate matter on average calendar day for counties in study area.
2. Suspended particulate (High-Volume Sampler) Data for Nassau and Westchester Counties, New York.
3. Settleable Particulate - Dustfall Data for Nassau and Westchester Counties, New York.
4. Emission inventory zone maps.
5. Frequency distributions of suspended particulate (high-volume sampler) data.
6. Frequency distributions of sulfate data.
7. Frequency distributions of acid particulate data.
8. Frequency distributions of suspended particulates (AISI samplers) data.
9. Frequency distributions of dustfall data.

Table D-1. EMISSION DENSITIES OF PARTICULATE MATTER ON AVERAGE CALENDAR DAY FOR BERGEN COUNTY

Zone	Area, mi^2	Density, $tons/mi^2$	Zone	Area, mi^2	Density, $tons/mi^2$
J-1-01	20.5	0.01	J-1-21	5.1	0.17
J-1-02	3.8	0.35	J-1-22	2.1	0.39
J-1-03	10.4	0.04	J-1-23	3.7	0.83
J-1-04	10.1	0.04	J-1-24	4.0	0.23
J-1-05	9.9	0.04	J-1-25	5.9	0.32
J-1-06	9.4	0.03	J-1-26	5.9	0.17
J-1-07	9.2	0.03	J-1-27	6.7	0.15
J-1-08	10.5	0.05	J-1-28	4.8	0.14
J-1-09	8.4	0.13	J-1-29	2.7	0.24
J-1-10	10.3	0.05	J-1-30	2.4	0.39
J-1-11	9.1	0.03	J-1-31	3.8	0.49
J-1-12	6.2	0.05	J-1-32	4.9	0.16
J-1-13	5.3	0.03	J-1-33	2.6	3.87
J-1-14	6.4	0.14	J-1-34	1.9	0.34
J-1-15	4.0	0.10	J-1-35	2.0	0.36
J-1-16	2.2	0.29	J-1-36	2.1	0.33
J-1-17	6.0	0.06	J-1-37	2.5	0.21
J-1-18	3.0	0.19	J-1-38	0.7	2.39
J-1-19	4.4	0.13	J-1-39	7.8	0.09
J-1-20	2.5	0.15	J-1-40	2.8	0.25

Table D-2. EMISSION DENSITIES OF PARTICULATE MATTER ON AVERAGE CALENDAR DAY FOR ESSEX COUNTY

Zone	Area, mi^2	Density, tons/mi^2	Zone	Area, mi^2	Density, tons/mi^2
J-2-01	12.4	0.03	J-2-21	2.2	0.19
J-2-02	4.5	0.26	J-2-22	1.5	0.61
J-2-03	11.5	0.05	J-2-23	1.1	1.04
J-2-04	2.8	0.13	J-2-24	1.0	1.21
J-2-05	3.8	0.18	J-2-25	1.0	0.65
J-2-06	2.7	0.19	J-2-26	1.6	1.17
J-2-07	3.4	0.22	J-2-27	1.5	2.57
J-2-08	14.0	0.04	J-2-28	1.5	0.68
J-2-09	8.4	0.05	J-2-29	1.5	0.91
J-2-10	2.3	0.23	J-2-30	0.9	0.93
J-2-11	2.7	0.25	J-2-31	0.9	1.03
J-2-12	2.9	0.30	J-2-32	5.6	0.08
J-2-13	1.7	0.59	J-2-33	4.8	0.05
J-2-14	3.5	0.20	J-2-34	3.0	0.17
J-2-15	2.3	0.37	J-2-35	1.4	0.71
J-2-16	2.2	0.60	J-2-36	1.8	0.34
J-2-17	2.4	0.41	J-2-37	1.5	0.48
J-2-18	1.6	0.57	J-2-38	4.1	0.24
J-2-19	1.2	0.63	J-2-39	2.5	0.15
J-2-20	1.1	0.52			

Table D-3. EMISSION DENSITIES OF PARTICULATE MATTER ON AVERAGE CALENDAR DAY FOR HUDSON COUNTY

Zone	Area, mi^2	Density, tons/mi^2	Zone	Area, mi^2	Density, tons/mi^2
J-3-01	2.6	0.42	J-3-15	1.2	5.36
J-3-02	1.1	0.55	J-3-16	3.3	2.56
J-3-03	6.1	0.16	J-3-17	1.0	0.35
J-3-04	0.9	1.28	J-3-18	1.1	1.05
J-3-05	1.5	0.31	J-3-19	2.0	3.36
J-3-06	0.5	1.04	J-3-20	0.7	2.79
J-3-07	0.7	0.66	J-3-21	1.4	0.63
J-3-08	0.5	1.30	J-3-22	2.2	0.14
J-3-09	1.9	3.39	J-3-23	2.6	0.38
J-3-10	1.4	0.55	J-3-24	1.2	0.45
J-3-11	0.7	2.27	J-3-25	1.5	0.76
J-3-12	0.5	3.54	J-3-26	2.5	0.41
J-3-13	0.6	1.13	J-3-27	4.1	0.06
J-3-14	0.9	0.89	J-3-28	1.3	2.47

Table D-4. EMISSION DENSITIES OF PARTICULATE MATTER ON AVERAGE CALENDAR DAY FOR MIDDLESEX COUNTY

Zone	Area, mi^2	Density, $tons/mi^2$	Zone	Area, mi^2	Density, $tons/mi^2$
J-4-01	9.0	0.10	J-4-18	1.6	4.93
J-4-02	8.2	0.20	J-4-19	1.8	1.60
J-4-03	11.8	0.02	J-4-20	1.3	0.49
J-4-04	4.0	0.12	J-4-21	2.4	0.31
J-4-05	6.5	0.12	J-4-22	2.8	0.23
J-4-06	5.1	0.13	J-4-23	13.4	0.07
J-4-07	2.0	0.34	J-4-24	41.4	0.02
J-4-08	1.6	0.63	J-4-25	11.7	0.03
J-4-09	3.5	3.47	J-4-26	13.1	0.03
J-4-10	0.8	3.77	J-4-27	19.9	0.03
J-4-11	4.8	0.73	J-4-28	8.1	0.07
J-4-12	9.4	0.05	J-4-29	6.2	0.60
J-4-13	5.1	0.09	J-4-30	7.3	2.44
J-4-14	4.6	0.13	J-4-31	3.8	1.16
J-4-15	4.1	0.14	J-4-32	2.9	0.13
J-4-16	10.0	0.09	J-4-33	44.0	0.01
J-4-17	4.5	0.16	J-4-34	44.4	0.01

Table D-5. EMISSION DENSITIES OF PARTICULATE MATTER ON AVERAGE CALENDAR DAY FOR MONMOUTH COUNTY

Zone	Area, mi^2	Density, tons/mi^2	Zone	Area, mi^2	Density, tons/mi^2
J-5-01	7.7	0.05	J-5-12	31.6	0.01
J-5-02	9.8	0.07	J-5-13	26.1	0.03
J-5-03	25.2	0.03	J-5-14	5.1	0.10
J-5-04	30.2	0.02	J-5-15	16.2	0.03
J-5-05	17.9	0.01	J-5-16	8.9	0.06
J-5-06	15.3	0.03	J-5-17	3.5	0.21
J-5-07	14.4	0.05	J-5-18	63.7	0.01
J-5-08	32.7	0.01	J-5-19	31.0	0.02
J-5-09	39.3	0.01	J-5-20	4.3	0.10
J-5-10	48.0	0.01	J-5-21	3.5	0.06
J-5-11	40.0	0.04			

Table D-6. EMISSION DENSITIES OF PARTICULATE MATTER ON AVERAGE CALENDAR DAY FOR MORRIS COUNTY

Zone	Area, mi^2	Density, tons/mi^2	Zone	Area, mi^2	Density, tons/mi^2
J-6-01	44.3	0.01	J-6-15	8.4	0.02
J-6-02	37.1	0.01	J-6-16	7.2	0.03
J-6-03	21.5	0.04	J-6-17	16.3	0.11
J-6-04	15.7	0.03	J-6-18	24.0	0.02
J-6-05	10.2	0.08	J-6-19	9.4	0.02
J-6-06	18.3	0.01	J-6-20	9.7	0.07
J-6-07	7.6	0.02	J-6-21	15.7	0.04
J-6-08	4.3	0.17	J-6-22	7.3	0.01
J-6-09	9.3	0.06	J-6-23	31.6	0.01
J-6-10	4.0	0.04	J-6-24	45.1	0.01
J-6-11	4.6	0.05	J-6-25	28.7	0.01
J-6-12	14.4	0.04	J-6-26	6.7	0.03
J-6-13	10.1	0.03	J-6-27	16.7	0.01
J-6-14	10.8	0.09	J-6-28	16.5	0.01

Table D-7. EMISSION DENSITIES OF PARTICULATE MATTER ON AVERAGE CALENDAR DAY FOR PASSAIC COUNTY

Zone	Area, mi^2	Density, $tons/mi^2$	Zone	Area, mi^2	Density, $tons/mi^2$
J-7-01	78.5	0.01	J-7-14	0.4	0.98
J-7-02	27.3	0.02	J-7-15	0.5	0.67
J-7-03	17.3	0.02	J-7-16	1.6	0.43
J-7-04	3.5	0.07	J-7-17	1.0	0.62
J-7-05	12.6	0.03	J-7-18	0.9	0.49
J-7-06	11.3	0.05	J-7-19	1.0	0.48
J-7-07	3.4	0.04	J-7-20	1.8	0.57
J-7-08	3.6	0.13	J-7-21	2.9	0.25
J-7-09	1.7	0.24	J-7-22	1.8	0.40
J-7-10	3.9	0.09	J-7-23	3.8	0.13
J-7-11	3.0	0.08	J-7-24	2.7	0.29
J-7-12	2.8	0.15	J-7-25	2.0	1.87
J-7-13	1.4	0.30	J-7-26	1.1	2.91

Table D-8. EMISSION DENSITIES OF PARTICULATE MATTER ON AVERAGE CALENDAR DAY FOR SOMERSET COUNTY

Zone	Area, mi^2	Density, tons/mi^2	Zone	Area, mi^2	Density, tons/mi^2
J-8-01	13.1	0.01	J-8-10	2.9	0.17
J-8-02	37.6	0.01	J-8-11	10.2	0.27
J-8-03	5.8	0.01	J-8-12	2.5	0.53
J-8-04	21.7	0.03	J-8-13	34.1	0.01
J-8-05	20.2	0.01	J-8-14	20.6	0.01
J-8-06	14.9	0.01	J-8-15	2.5	1.03
J-8-07	14.1	0.02	J-8-16	10.1	0.01
J-8-08	19.3	0.01	J-8-17	9.0	0.03
J-8-09	10.9	0.04	J-8-18	32.3	0.01
			J-8-19	27.3	0.01

Table D-9. EMISSION DENSITIES OF PARTICULATE MATTER ON AVERAGE CALENDAR DAY FOR UNION COUNTY

Zone	Area, mi^2	Density, $tons/mi^2$	Zone	Area, mi^2	Density, $tons/mi^2$
J-9-01	10.2	0.05	J-9-13	4.9	0.27
J-9-02	6.0	0.15	J-9-14	2.7	0.22
J-9-03	3.0	0.21	J-9-15	4.5	0.23
J-9-04	2.8	0.23	J-9-16	2.7	0.30
J-9-05	4.2	0.13	J-9-17	4.1	0.55
J-9-06	7.0	0.08	J-9-18	3.0	0.28
J-9-07	5.2	0.12	J-9-19	2.2	0.48
J-9-08	5.8	0.03	J-9-20	1.9	0.50
J-9-09	4.1	0.15	J-9-21	4.3	0.19
J-9-10	4.9	0.14	J-9-22	1.8	0.55
J-9-11	3.4	0.25	J-9-23	1.4	0.65
J-9-12	4.2	0.18	J-9-24	7.7	1.50

Table D-10. EMISSION DENSITIES OF PARTICULATE MATTER ON AVERAGE CALENDAR DAY FOR BRONX COUNTY

Zone	Area, mi^2	Density, $tons/mi^2$
Y-1-01	0.4	0.10
Y-1-02	0.9	0.11
Y-1-03	1.3	0.14
Y-1-04	0.8	0.38
Y-1-05	1.1	0.51
Y-1-06	0.2	0.40
Y-1-07	1.0	0.56
Y-1-08	1.0	0.50
Y-1-09	1.0	0.61
Y-1-10	1.0	0.46
Y-1-11	1.0	0.19
Y-1-12	2.0	0.06
Y-1-13	0.6	1.51
Y-1-14	1.0	1.44
Y-1-15	1.0	0.59
Y-1-16	1.0	0.36
Y-1-17	1.0	0.16
Y-1-18	1.0	0.01
Y-1-19	1.0	0.12
Y-1-20	0.2	1.12
Y-1-21	1.0	2.16
Y-1-22	1.0	1.85
Y-1-23	1.0	0.45
Y-1-24	1.0	0.37
Y-1-25	1.0	0.29
Y-1-26	0.7	1.76
Y-1-27	1.0	2.15
Y-1-28	1.0	0.93
Y-1-29	1.0	0.78
Y-1-30	1.0	0.87
Y-1-31	1.0	0.39
Y-1-32	0.5	0.22
Y-1-34	0.8	1.23
Y-1-35	1.0	2.04
Y-1-36	1.0	2.14
Y-1-37	1.0	0.64
Y-1-38	1.0	2.53
Y-1-39	1.0	0.24
Y-1-40	1.1	0.38
Y-1-41	0.8	1.09
Y-1-42	1.0	2.15
Y-1-43	1.0	0.84
Y-1-44	0.9	0.45
Y-1-45	1.6	0.08
Y-1-47	0.6	4.97
Y-1-48	0.9	0.01

Table D-11. EMISSION DENSITIES OF PARTICULATE MATTER ON AVERAGE CALENDAR DAY FOR KINGS COUNTY

Zone	Area, mi^2	Density, tons/mi^2	Zone	Area, mi^2	Density, tons/mi^2
Y-2-01	0.2	0.48	Y-2-25	1.0	5.44
Y-2-02	0.3	9.10	Y-2-26	1.0	0.94
Y-2-03	0.4	0.54	Y-2-27	1.0	0.58
Y-2-04	1.0	1.13	Y-2-28	1.0	0.90
Y-2-05	0.4	0.68	Y-2-29	1.0	1.13
Y-2-06	0.2	27.54	Y-2-30	1.0	1.48
Y-2-07	0.8	3.54	Y-2-31	1.0	1.04
Y-2-08	1.0	1.16	Y-2-32	1.2	4.33
Y-2-09	0.9	0.81	Y-2-33	0.5	0.82
Y-2-10	0.4	1.26	Y-2-34	1.0	0.62
Y-2-11	1.0	1.15	Y-2-35	1.0	0.36
Y-2-12	1.0	0.67	Y-2-36	1.0	0.85
Y-2-13	1.0	1.00	Y-2-37	1.0	1.82
Y-2-14	1.0	0.96	Y-2-38	1.0	0.70
Y-2-15	0.6	0.85	Y-2-39	1.0	0.54
Y-2-16	0.2	0.30	Y-2-40	1.0	0.27
Y-2-17	1.2	0.59	Y-2-41	1.0	0.07
Y-2-18	1.0	1.73	Y-2-42	0.2	0.82
Y-2-19	1.0	2.86	Y-2-43	1.0	0.81
Y-2-20	1.0	1.10	Y-2-44	1.0	0.85
Y-2-21	1.0	1.94	Y-2-45	1.0	0.87
Y-2-22	1.0	0.80	Y-2-46	1.0	0.78
Y-2-23	0.8	0.80	Y-2-47	1.0	0.64
Y-2-24	0.8	0.35	Y-2-48	1.0	0.33

Table D-11 (continued). EMISSION DENSITIES OF PARTICULATE MATTER ON AVERAGE CALENDAR DAY FOR KINGS COUNTY

Zone	Area, mi^2	Density, tons/mi^2	Zone	Area, mi^2	Density, tons/mi^2
Y-2-49	1.0	0.31	Y-2-63	1.0	0.79
Y 2-50	1.0	0.20	Y-2-64	1.0	0.70
Y-2-51	1.0	0.11	Y-2-65	1.0	0.59
Y-2-52	0.5	0.62	Y-2-66	1.0	0.72
Y-2-53	1.0	0.74	Y-2-67	0.5	0.56
Y-2-54	1.0	0.67	Y-2-68	1.0	2.95
Y-2-55	1.0	0.62	Y-2-69	1.0	0.49
Y-2-56	1.0	0.52	Y-2-70	1.0	0.69
Y-2-57	1.0	0.47	Y-2-71	1.0	0.18
Y-2-58	1.0	0.38	Y-2-72	6.5	0.03
Y-2-59	2.0	0.13	Y-2-73	0.5	0.71
Y-2-60	1.0	0.00	Y-2-74	1.0	0.40
Y-2-61	0.2	0.92	Y-2-75	1.0	0.77
Y-2-62	0.9	0.14	Y-2-76	0.8	0.41
			Y-2-77	0.8	0.13
			Y-2-78	1.0	0.25

Table D-12. EMISSION DENSITIES OF PARTICULATE MATTER ON AVERAGE CALENDAR DAY FOR RICHMOND COUNTY

Zone	Area, mi^2	Density, tons/mi^2	Zone	Area, mi^2	Density, tons/mi^2
Y-3-01	3.5	0.12	Y-3-11	3.8	0.10
Y-3-02	3.6	0.19	Y-3-12	0.7	0.05
Y-3-03	4.1	0.13	Y-3-13	3.9	0.03
Y-3-04	2.2	0.47	Y-3-14	4.0	0.03
Y-3-05	4.3	0.02	Y-3-15	3.1	0.05
Y-3-06	4.0	0.14	Y-3-16	0.8	0.02
Y-3-07	4.0	0.06	Y-3-17	0.9	0.06
Y-3-08	3.2	0.07	Y-3-18	3.5	0.12
Y-3-09	4.5	0.59	Y-3-19	1.5	0.02
Y-3-10	4.0	0.03			

Table D-13. EMISSION DENSITIES OF PARTICULATE MATTER ON AVERAGE CALENDAR DAY FOR NEW YORK COUNTY

Zone	Area, mi^2	Density, tons/mi^2	Zone	Area, mi^2	Density, tons/mi^2
Y-4-01	0.8	0.92	Y-4-18	0.4	0.41
Y-4-02	0.3	9.08	Y-4-19	0.2	13.56
Y-4-03	0.4	1.13	Y-4-20	1.0	4.60
Y-4-04	0.7	6.15	Y-4-21	1.0	2.02
Y-4-05	0.7	1.92	Y-4-22	0.4	16.61
Y-4-06	0.2	1.62	Y-4-23	0.7	1.37
Y-4-07	0.2	0.93	Y-4-24	1.0	1.61
Y-4-08	1.0	2.32	Y-4-25	0.8	11.83
Y-4-09	0.6	3.10	Y-4-26	1.0	7.02
Y-4-10	1.1	3.12	Y-4-27	1.1	4.73
Y-4-11	0.2	2.03	Y-4-28	1.0	1.27
Y-4-12	1.0	2.60	Y-4-29	1.1	10.65
Y-4-13	1.0	2.64	Y-4-30	0.2	1.82
Y-4-14	0.7	1.15	Y-4-31	0.8	0.96
Y-4-15	0.6	3.91	Y-4-32	0.4	2.81
Y-4-16	1.0	1.49	Y-4-33	0.4	0.25
Y-4-17	0.8	2.51			

Table D-14. EMISSION DENSITIES OF PARTICULATE MATTER ON AVERAGE CALENDAR DAY FOR QUEENS COUNTY

Zone	Area, mi^2	Density, tons/mi^2	Zone	Area, mi^2	Density, tons/mi^2
Y-5-01	0.8	14.19	Y-5-23	1.0	0.51
Y-5-02	2.2	0.46	Y-5-24	1.0	0.39
Y-5-03	3.2	0.76	Y-5-25	1.0	0.62
Y-5-04	4.6	0.34	Y-5-26	1.0	0.82
Y-5-05	3.8	0.24	Y-5-27	4.0	0.55
Y-5-06	1.3	0.82	Y-5-28	4.0	0.28
Y-5-07	1.0	0.82	Y-5-29	4.5	0.27
Y-5-08	1.0	5. 86	Y-5-30	1.1	0.50
Y-5-09	1.0	0.63	Y-5-31	1.0	0.27
Y-5-10	1.0	1.06	Y-5-32	1.0	0.36
Y-5-11	1.0	0.76	Y-5-33	1.0	0.35
Y-5-12	1.0	0.83	Y-5-34	1.7	0.34
Y-5-13	4.0	0.47	Y-5-35	3.0	0.39
Y-5-14	4.0	0.32	Y-5-36	4.0	0.31
Y-5-15	4.0	0.34	Y-5-37	4.0	0.32
Y-5-16	4.6	0.27	Y-5-38	4.1	0.24
Y-5-17	1.0	0.59	Y-5-39	3.5	0.21
Y-5-18	1.0	0.76	Y-5-40	4.9	0.27
Y-5-19	1.0	3.45	Y-5-41	8.0	0.27
Y-5-20	1.0	0.58	Y-5-42	4.6	0.16
Y-5-21	1.0	0.71	Y-5-43	1.8	0.17
Y-5-22	0.6	1.50	Y-5-44	1.6	0.16

Table D-15. EMISSION DENSITIES OF PARTICULATE MATTER
ON AVERAGE CALENDAR DAY FOR NASSAU COUNTY

Zone	Area, mi^2	Density, $tons/mi^2$	Zone	Area, mi^2	Density, $tons/mi^2$
Y-6-01	5.0	0.12	Y-6-21	7.0	0.11
Y-6-02	9.0	0.05	Y-6-22	6.0	0.05
Y-6-03	7.6	0.03	Y-6-23	7.0	0.67
Y-6-04	6.6	0.11	Y-6-24	2.2	0.13
Y-6-05	2.0	0.08	Y-6-25	5.1	0.16
Y-6-06	4.0	0.05	Y-6-26	3.0	0.06
Y-6-07	4.0	0.01	Y-6-27	4.0	0.04
Y-6-08	8.0	0.01	Y-6-28	6.0	0.09
Y-6-09	3.0	0.10	Y-6-29	3.2	0.16
Y-6-10	6.0	0.04	Y-6-30	3.8	0.05
Y-6-11	6.0	0.20	Y-6-31	3.8	0.26
Y-6-12	4.8	0.12	Y-6-32	3.5	0.08
Y-6-13	2.5	0.11	Y-6-33	3.2	0.10
Y-6-14	3.0	0.43	Y-6-34	9.0	0.08
Y-6-15	2.5	0.14	Y-6-35	5.0	0.06
Y-6-16	7.0	0.06	Y-6-36	4.0	0.06
Y-6-17	5.0	0.12	Y-6-37	3.6	0.22
Y-6-18	13.0	0.03	Y-6-38	3.7	0.09
Y-6-19	6.5	0.06	Y-6-39	3.1	0.17
Y-6-20	5.0	0.03	Y-6-40	2.2	0.17

Table D-15 (continued). EMISSION DENSITIES OF PARTICULATE MATTER ON AVERAGE CALENDAR DAY FOR NASSAU COUNTY

Zone	Area, mi^2	Density, $tons/mi^2$	Zone	Area, mi^2	Density, $tons/mi^2$
Y-6-41	2.0	0.09	Y-6-51	4.8	0.02
Y-6-42	3.0	0.06	Y-6-52	4.6	1.00
Y-6-43	3.5	0.06	Y-6-53	4.6	0.06
Y-6-44	4.2	0.06	Y-6-54	3.4	0.06
Y-6-45	5.0	0.06	Y-6-55	5.0	0.07
Y-6-46	7.0	0.04	Y-6-56	3.7	0.06
Y-6-47	4.0	0.27	Y-6-57	5.0	0.07
Y-6-48	2.1	1.64	Y-6-58	7.5	0.05
Y-6-49	6.2	0.12	Y-6-59	7.0	0.01
Y-6-50	2.1	0.93	Y-6-60	2.0	0.02

Table D-16. EMISSION DENSITIES OF PARTICULATE MATTER ON AVERAGE CALENDAR DAY FOR ROCKLAND COUNTY

Zone	Area, mi^2	Density, $tons/mi^2$	Zone	Area, mi^2	Density, $tons/mi^2$
Y-7-01	24.3	0.40	Y-7-09	12.7	0.03
Y-7-02	3.5	0.69	Y-7-10	13.6	0.01
Y-7-03	19.5	0.03	Y-7-11	13.6	0.05
Y-7-04	3.7	0.84	Y-7-12	13.8	0.03
Y-7-05	2.9	0.02	Y-7-13	2.3	0.08
Y-7-06	28.1	0.01	Y-7-14	6.7	0.24
Y-7-07	12.5	0.04	Y-7-15	6.7	0.17
Y-7-08	4.1	0.20	Y-7-16	6.7	0.03

Table D-17 EMISSION DENSITIES OF PARTICULATE MATTER ON AVERAGE CALENDAR DAY FOR WESTCHESTER COUNTY

Zone	Area, mi^2	Density, tons/mi^2	Zone	Area, mi^2	Density, tons/mi^2
Y-8-01	6.0	0.02	Y-8-26	5.2	0.34
Y-8-02	4.5	0.64	Y-8-27	4.9	0.06
Y-8-03	5.7	0.14	Y-8-28	6.5	0.05
Y-8-04	26.2	0.01	Y-8-29	10.3	0.01
Y-8-05	5.2	0.03	Y-8-30	10.3	0.06
Y-8-06	15.0	0.02	Y-8-31	2.2	0.36
Y-8-07	24.6	0.01	Y-8-32	5.0	0.09
Y-8-08	32.6	0.01	Y-8-33	3.3	0.16
Y-8-09	22.9	0.01	Y-8-34	3.0	0.09
Y-8-10	16.0	0.01	Y-8-35	1.0	0.27
Y-8-11	12.6	0.01	Y-8-36	4.0	0.53
Y-8-12	28.5	0.05	Y-8-37	5.1	0.10
Y-8-13	23.3	0.01	Y-8-38	2.0	0.12
Y-8-14	23.6	0.01	Y-8-39	0.3	30.15
Y-8-15	2.8	0.07	Y-8-40	1.0	0.62
Y-8-16	26.1	0.01	Y-8-41	4.5	0.20
Y-8-17	4.0	0.26	Y-8-42	5.0	0.12
Y-8-18	4.1	0.02	Y-8-43	1.7	0.16
Y-8-19	9.6	0.02	Y-8-44	3.1	0.04
Y-8-20	8.2	0.01	Y-8-45	4.2	0.12
Y-8-21	6.0	0.01	Y-8-46	3.1	0.55
Y-8-22	5.2	0.09	Y-8-47	2.5	0.26
Y-8-23	7.3	0.05	Y-8-48	1.9	0.85
Y-8-24	7.2	0.03	Y-8-49	2.2	0.17
Y-8-25	13.6	0.03			

TABLE D-18. HIGH-VOLUME SAMPLER SUSPENDED PARTICULATE RESULTS FOR WESTCHESTER COUNTY, N.Y.

(Monthly Average, ug/m^3)

DATE	WHITE PLAINS	OSSINING	SOMERS
January '65	97	90	56
February '65	113	78	74
March '65	74	57	49
April '65	69	59	45
May '65	95	87	72
June '65	84	77	59
July '65	83	75	63
August '65	71	67	57
September '65	100	78	64
October '65	107	49	44
November '65	109	94	60
December '65	104	79	58
January '66	68	66	34
February '66	110	97	56
March '66	102	85	65
April '66	97	76	53
May '66	96	81	63
June '66	-	-	-
July '66	111	86	70
August '66	71	55	36
September '66	78	40	34
October '66	88	61	45
November '66	134	87	57
December '66	78	85	64
January '67	104	83	58
February '67	65	85	62
March '67	70	114	75
April '67	61	66	40
May '67	67	60	62
June '67	115	102	104
July '67	106	67	69

TABLE D-19. HIGH-VOLUME SAMPLER SUSPENDED PARTICULATE RESULTS FOR NASSAU COUNTY, N.Y.
(Monthly averages, ug/m^3)

STATION	Jan. 1966	Feb. 1966	Mar. 1966	Apr. 1966	May 1966	June 1966	July 1966	Aug. 1966	Sept 1966	Oct. 1966	Nov. 1966	Dec. 1966	Jan. 1967	Feb. 1967	Mar. 1967	Apr. 1967	May 1967	June 1967	July 1967	Aug. 1967
Oyster Bay	83	113	102	67	126	83	112	74	61	111	56	104	120	75	71	58	83	87	81	93
New Cassel	90	88	108	108	149	104	136	82	64	103	104	106	142	84	101	84	89	74	86	106
Inwood	54	78	88	86	74	85	89	67	55	84	69	111	157	104	107	80	94	44	-	89
Rockville Centre	116	97	105	83	88	84	79	83	82	118	115	124	144	-	139	95	115	91	106	114
Massapequa	100	75	76	100	91	84	88	64	76	95	77	104	237	94	112	94	105	71	78	140
Oceanside	-	-	-	-	-	-	-	-	-	-	-	-	-	66	120	138	89	138	107	112
Glen Cove	90	116	104	122	93	119	163	115	99	147	135	123	211	118	130	105	92	147	116	154
Freeport	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	81	116	66	97	134
Kings Point	138	98	126	100	83	149	168	96	88	108	112	112	144	91	96	102	81	74	105	133
Plainview	122	86	82	88	126	118	102	61	47	75	88	73	105	69	65	62	75	85	79	88

TABLE D-20.
DUSTFALL-SETTLEABLE PARTICULATE
NASSAU COUNTY, N.Y.

Tons/mi^2- Mo.

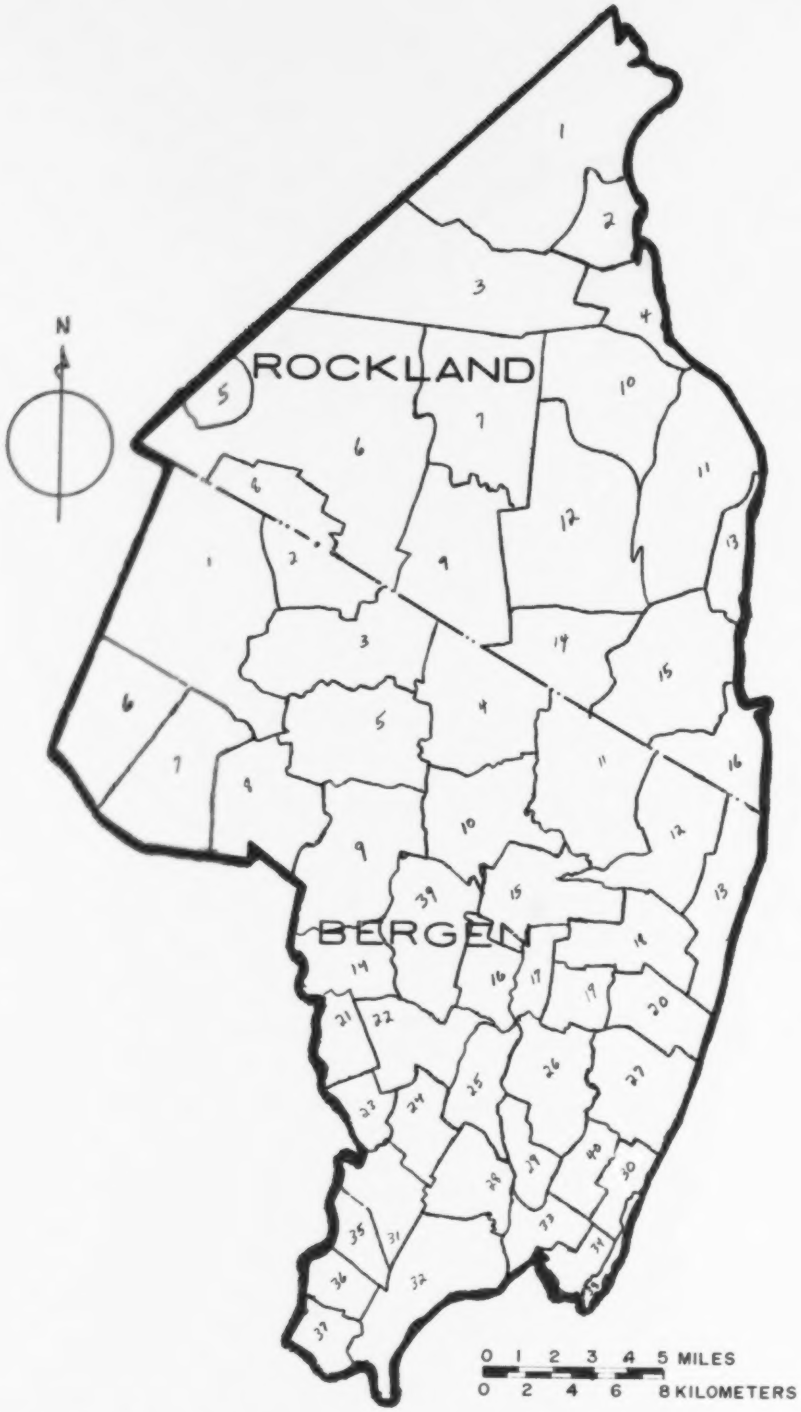
STATION	Dec. 1965	Jan. 1966	Feb. 1966	Mar. 1966	Apr. 1966	May 1966	June 1966	July 1966	Aug. 1966	Sept. 1966	Oct. 1966	Nov. 1966	Dec. 1966	Jan. 1967	Feb. 1967	Mar. 1967	Apr. 1967	May 1967	June 1967	July 1967
Elmont	4	14	13	9	8	11	7	5	5	11	12	5	7	11	14	14	22	12	13	10
Freeport	10	7	6	7	14	13	11	12	11	9	8	4	7	5	8	7	11	10	23	292
Glen Cove	8	16	15	9	9	11	10	6	7	10	10	9	11	12	12	-	16	13	25	12
Inwood	8	-	14	11	14	12	9	11	9	10	12	5	9	32	98	14	35	45	23	10
Kings Point	9	20	16	10	9	11	10	10	6	11	10	10	35	55	30	-	22	13	17	10
Massapequa	8	8	-	8	10	10	6	4	7	9	7	6	8	7	9	11	41	42	14	8
Mineola	8	14	14	9	11	8	8	6	7	11	9	8	9	23	9	12	11	10	7	8
New Cassel	11	5	13	8	7	8	42	8	8	9	6	5	272	7	-	13	9	-	21	9
Oceanside	7	58	-	17	20	12	10	125	14	20	14	7	295	59	207	30	20	19	24	12
Oyster Bay	9	-	8	8	9	7	8	5	7	9	8	7	-	9	12	-	13	17	16	13
Rockville Centre	8	10	8	-	11	12	8	8	9	11	9	5	10	9	19	-	19	17	28	14
Roslyn	14	64	27	18	21	18	9	10	19	13	21	62	30	29	36	-	67	21	22	11
Plainview	7	15	8	8	9	12	17	13	10	8	8	6	9	7	10	-	13	16	24	14
Tobay Beach	6	-	-	-	-	-	21	26	32	-	-	-	-	9	12	7	-	41	65	408

TABLE D-21

WESTCHESTER COUNTY DEPARTMENT OF HEALTH

Dustfall Data - mg/cm^2/30 days

Date	White Plains	Ossining	Somers	Rye	Peekskill
January '66	1.00	0.37	0.15	-	-
February '66	0.57	0.46	-	-	-
March '66	0.43	0.25	0.14	-	-
April '66	0.46	0.34	0.15	-	-
May '66	0.57	0.37	0.25	-	-
June '66	0.42	0.29	0.14	-	-
July '66	0.45	0.23	0.24	-	-
August '66	0.21	0.12	0.04	-	-
September '66	0.42	0.23	0.17	-	-
October '66	0.44	0.29	0.23	-	-
November '66	0.52	0.37	-	-	-
December '66	0.42	0.23	0.13	-	-
January '67	0.55	0.35	0.15	-	-
February '67	0.61	0.47	0.19	-	-
March	0.70	0.51	0.27	-	-
April '67	0.70	0.53	0.39	-	-
May '67	0.54	0.34	0.18	0.37	0.45
June '67	0.43	0.35	0.22	0.29	0.46
July '67	0.40	0.30	0.21	0.25	0.34


N
ROCKLAND
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32
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36
37
0 1 2 3 4 5 MILES
0 2 4 6 8 KILOMETERS

Figure D-1. Emission zones for Rockland (Y-7) and Bergen (J-1).

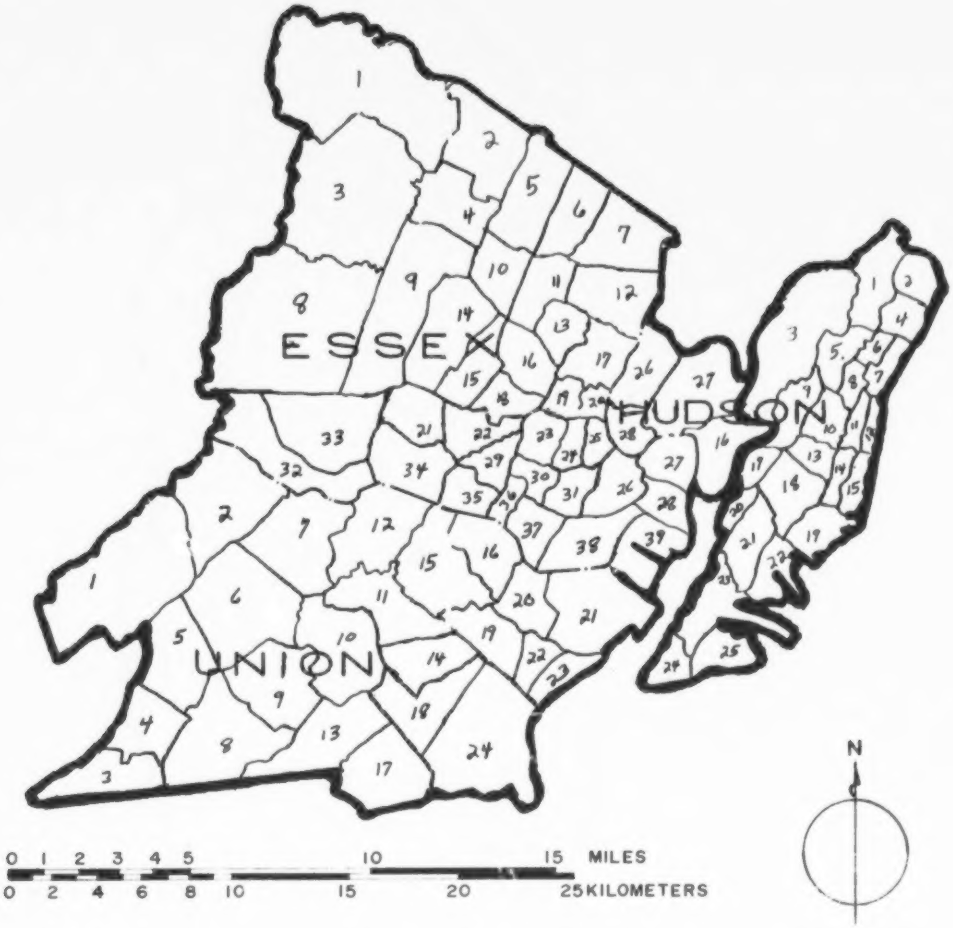
ESSEX
HUDSON
UNION
N
0 1 2 3 4 5 10 15 MILES
0 2 4 6 8 10 15 20 25 KILOMETERS

Figure D-2. Emission zones for Essex (J-2), Hudson (J-3), and Union (J-9).

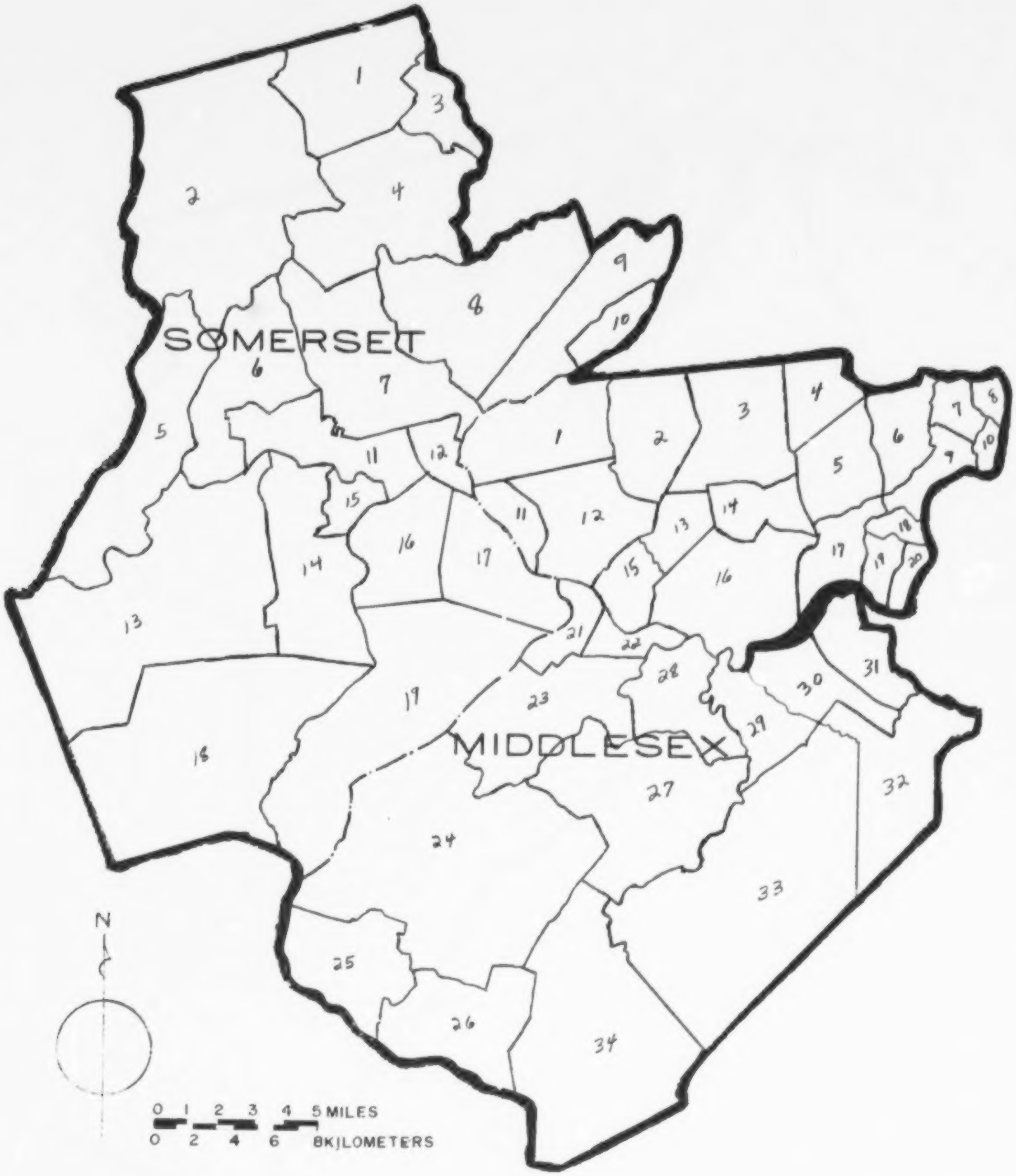
SOMERSET
MIDDLESEX
N
0 1 2 3 4 5 MILES
0 2 4 6 8 KILOMETERS
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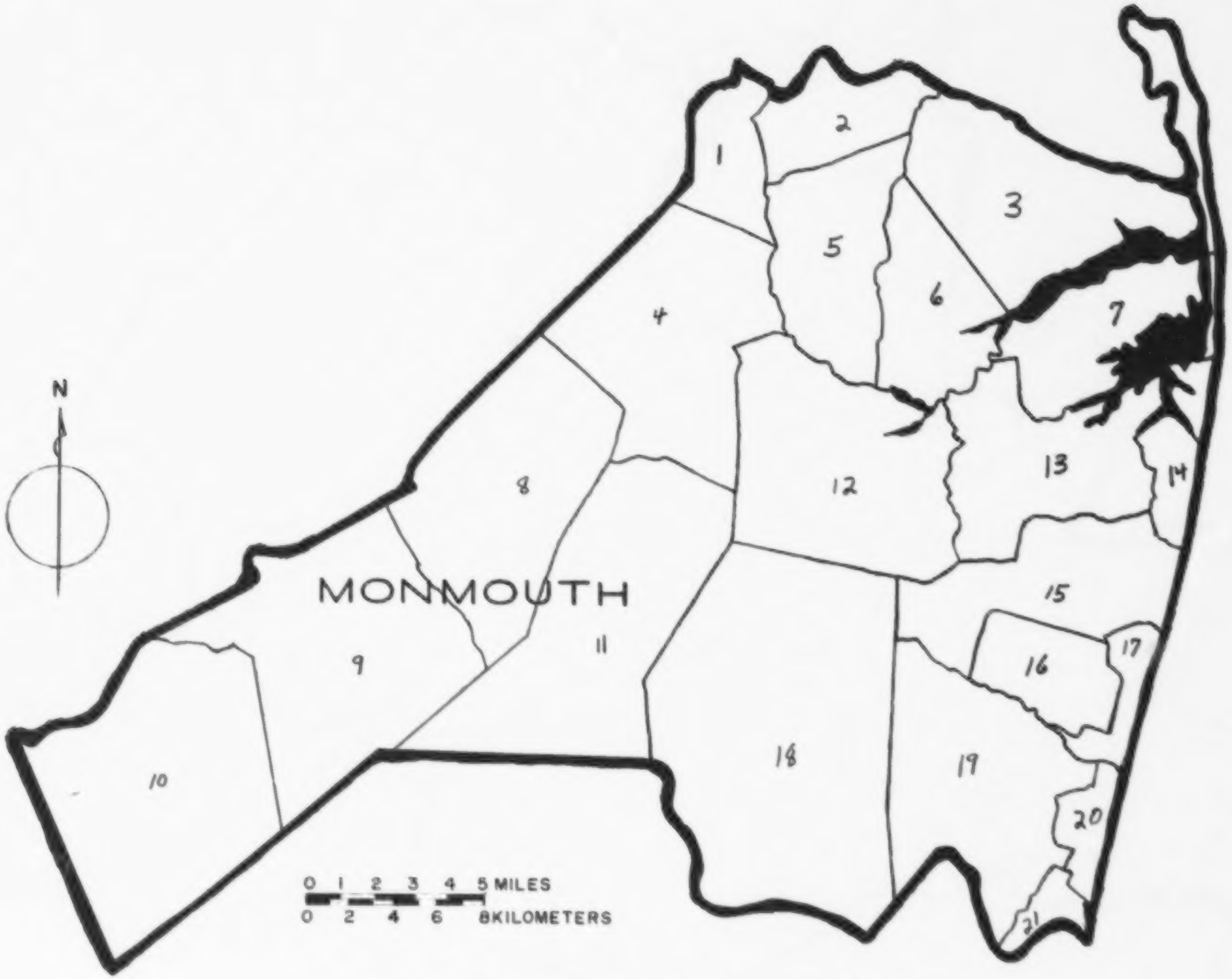
Figure D-3. Emission zones for Middlesex (J-4) and Somerset (J-8).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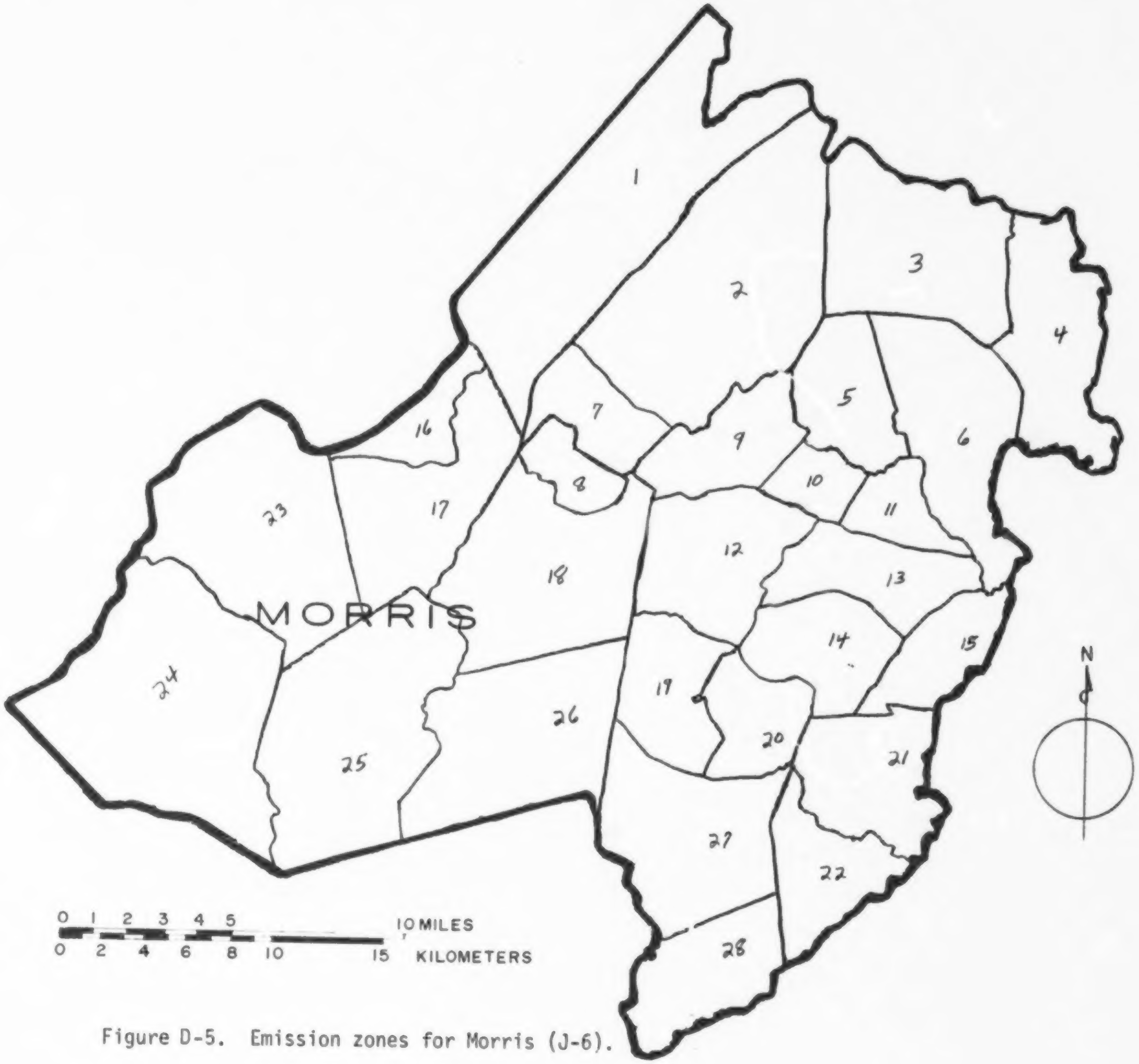
MONMOUTH
N
0 1 2 3 4 5 MILES
0 2 4 6 8 KILOMETERS

Figure D-4. Emission zones for Monmouth (J-5).


MORRIS
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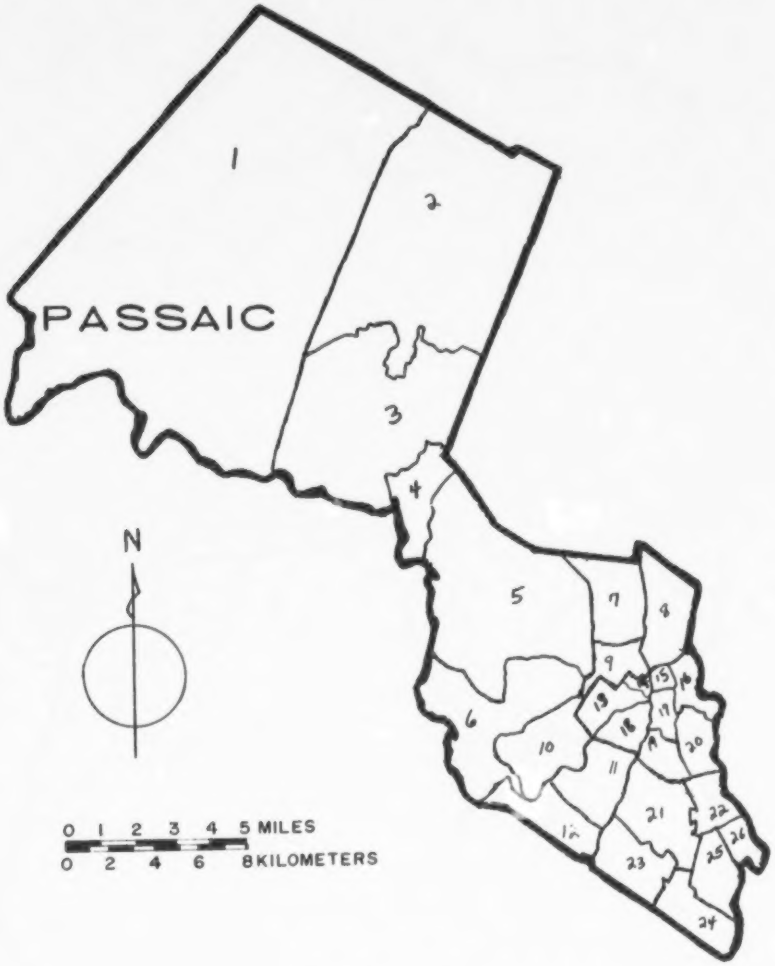
28
N
0 1 2 3 4 5 10 MILES
0 2 4 6 8 10 15 KILOMETERS

Figure D-5. Emission zones for Morris (J-6).


PASSAIC
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24
25
26
N
0 1 2 3 4 5 MILES
0 2 4 6 8 KILOMETERS

Figure D-6. Emission zones for Passaic (J-7).

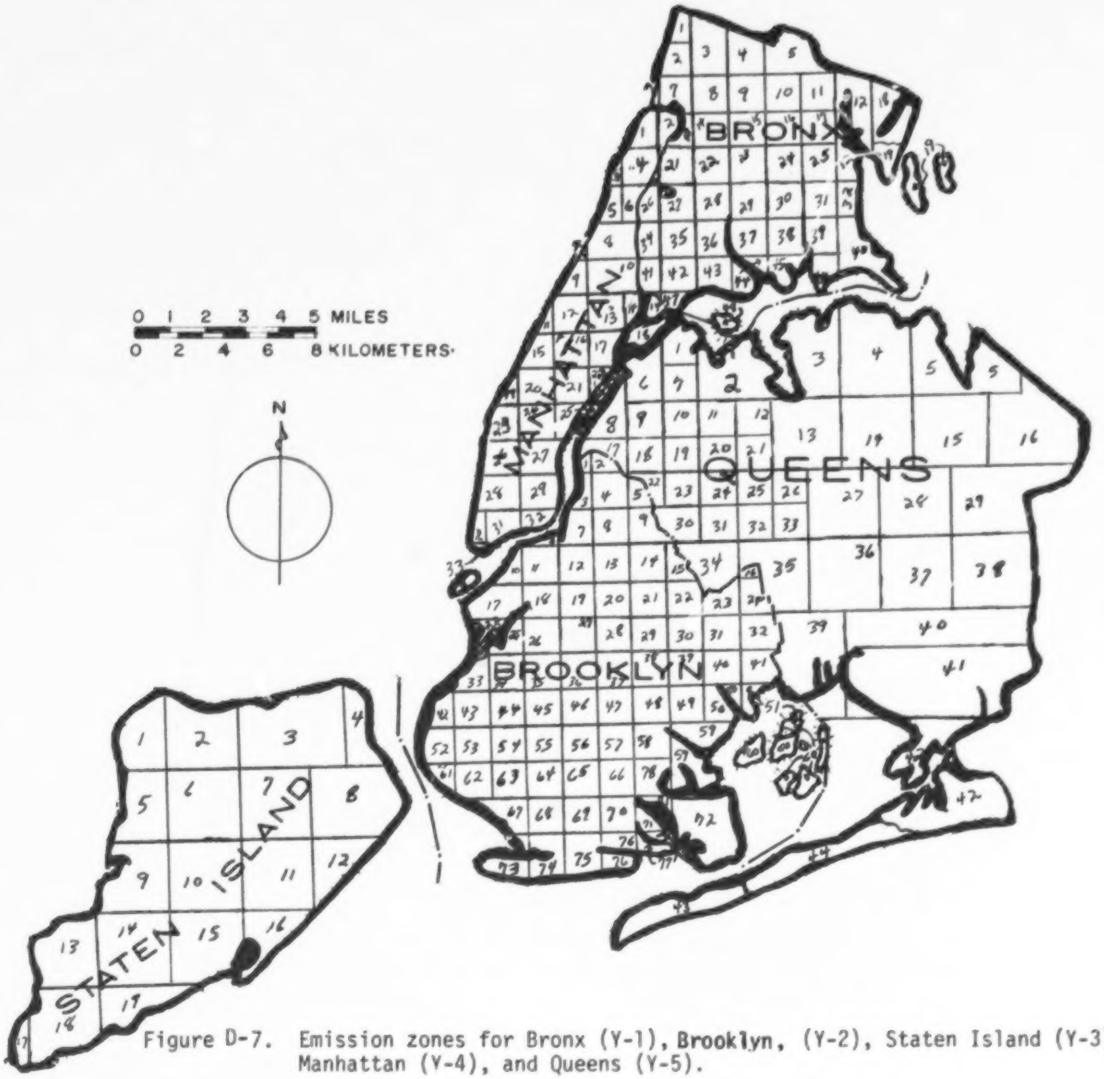
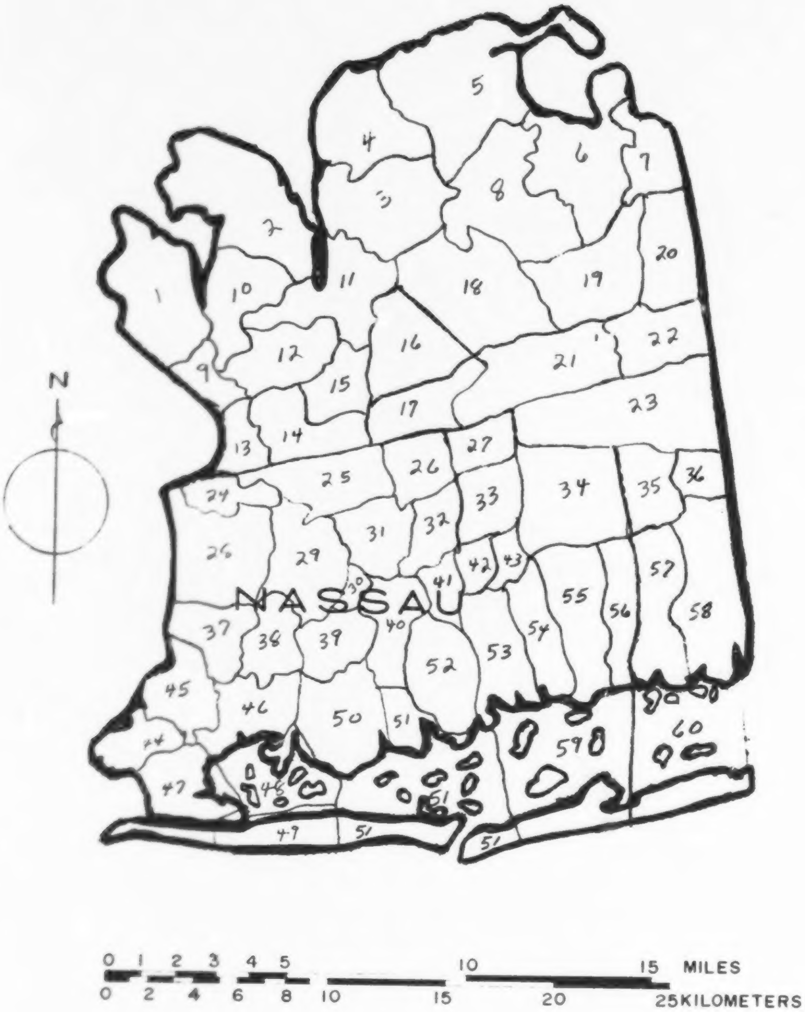

0 1 2 3 4 5 MILES
0 2 4 6 8 KILOMETERS
N
BRONX
MANHATTAN
QUEENS
BROOKLYN
STATEN ISLAND

Figure D-7. Emission zones for Bronx (Y-1), **Brooklyn**, (Y-2), Staten Island (Y-3), Manhattan (Y-4), and Queens (Y-5).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NASSAU
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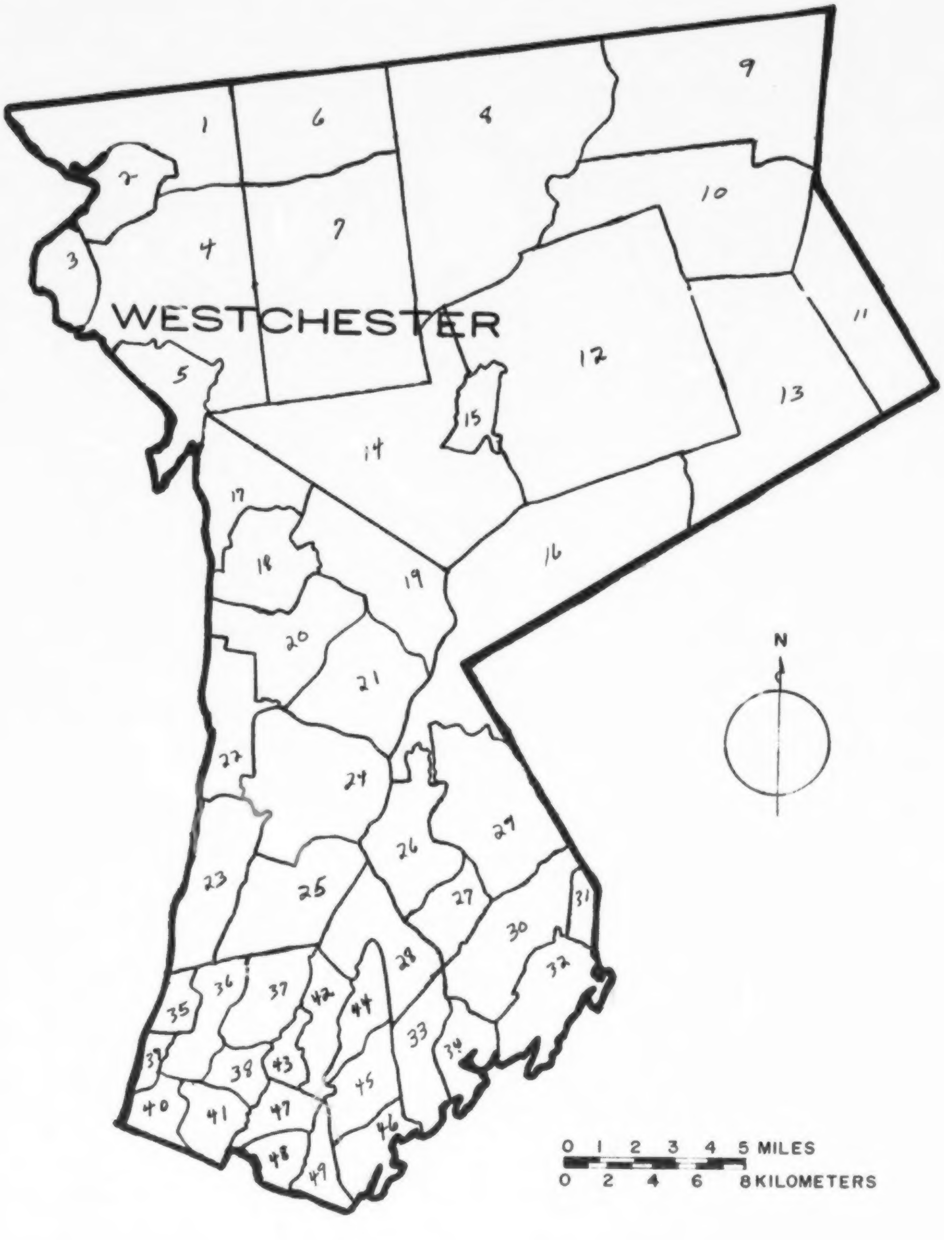
0 1 2 3 4 5 10 15 MILES
0 2 4 6 8 10 15 20 25KILOMETERS

Figure D-8. Emission zones for Nassau (Y-6).


WESTCHESTER
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N
0 1 2 3 4 5 MILES
0 2 4 6 8 KILOMETERS

Figure D-9. Emission zones for Westchester (Y-8).

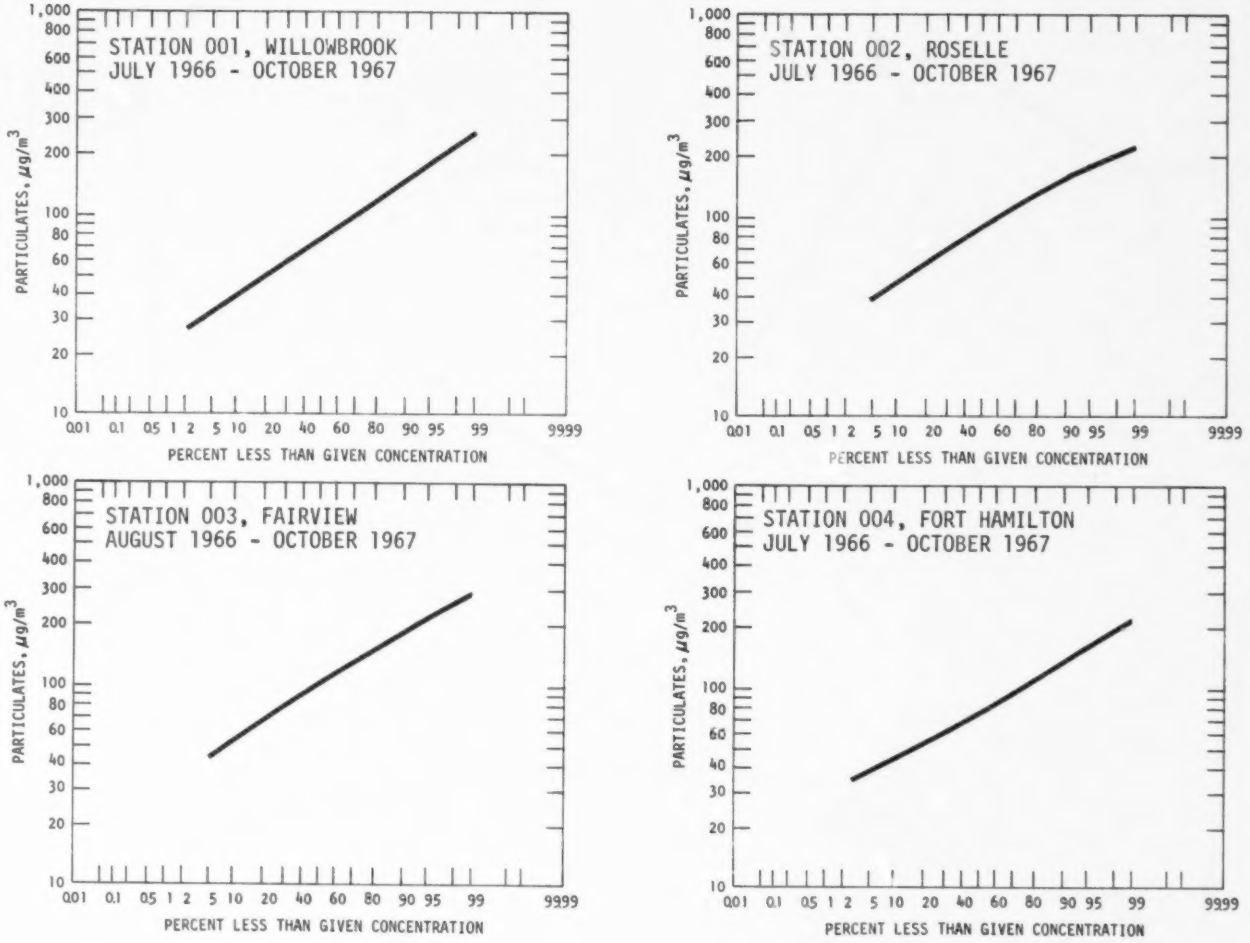

Figure D-10. Frequency distributions of suspended particulate - by high-volume samplers - at stations 001, 002, 003, and 004.

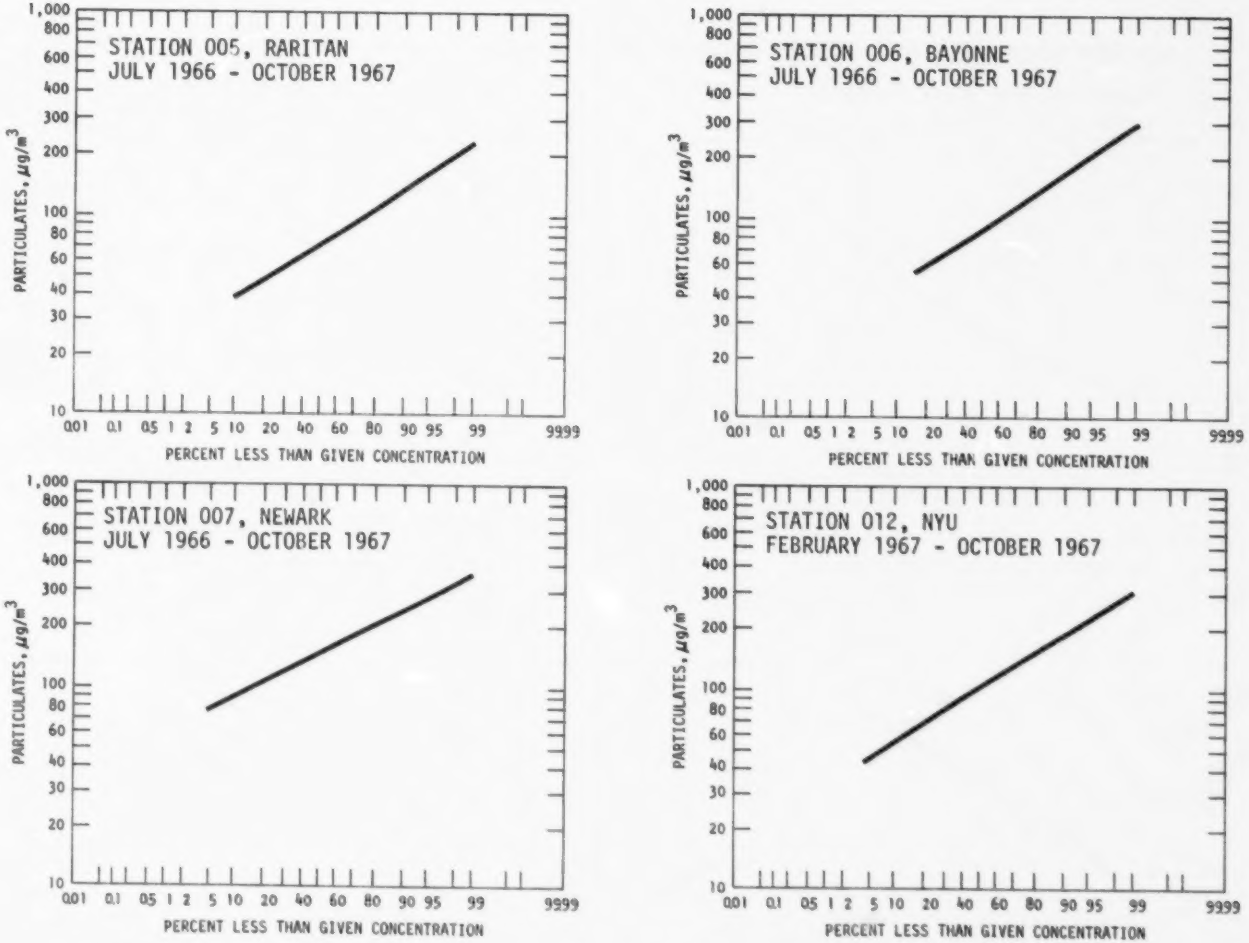

Figure D-11. Frequency distributions of suspended particulate - by high-volume samplers - at stations 005, 006, 007, and 012.

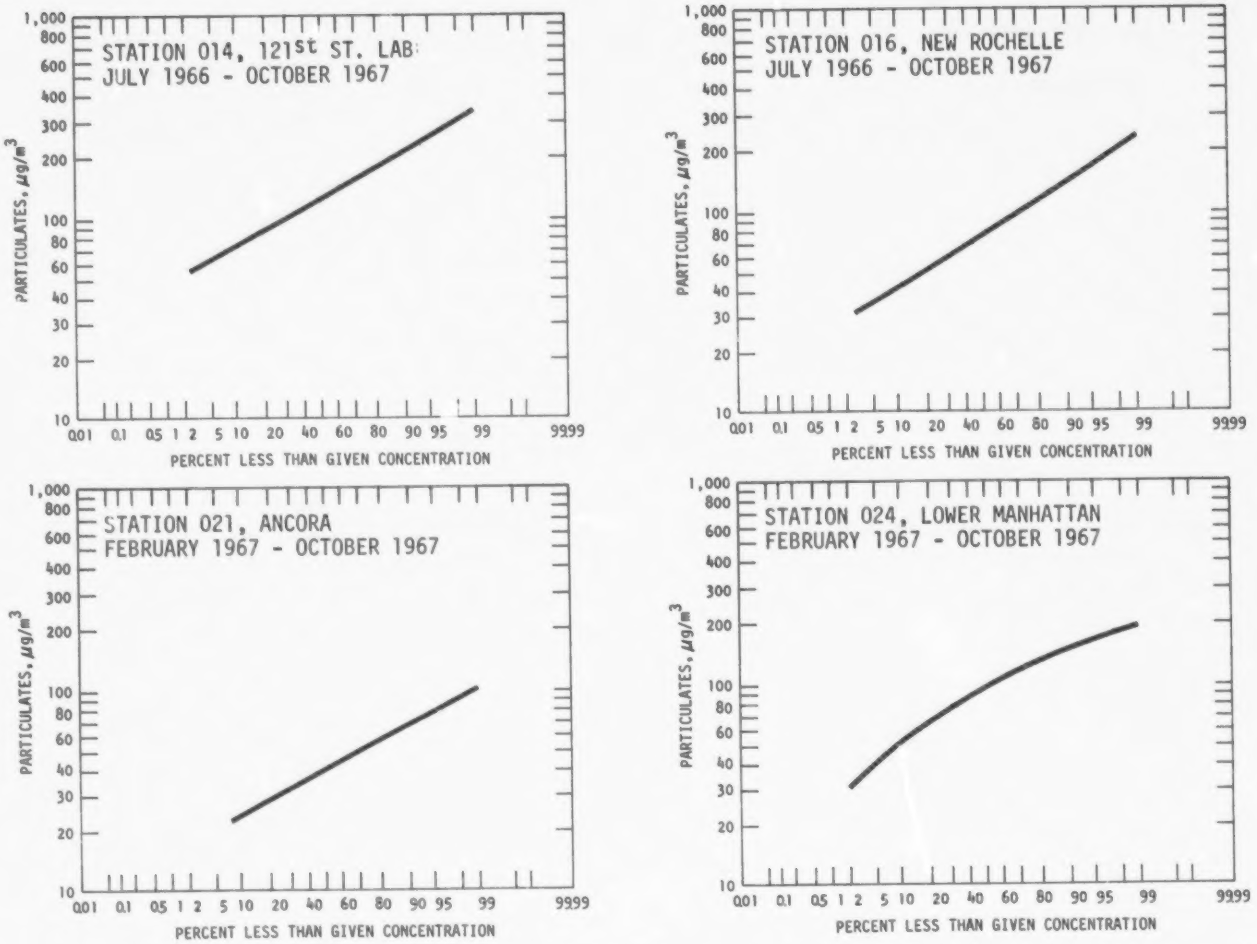

Figure D-12. Frequency distributions of suspended particulate - by high-volume samplers - at stations 014, 016, 021, and 024.

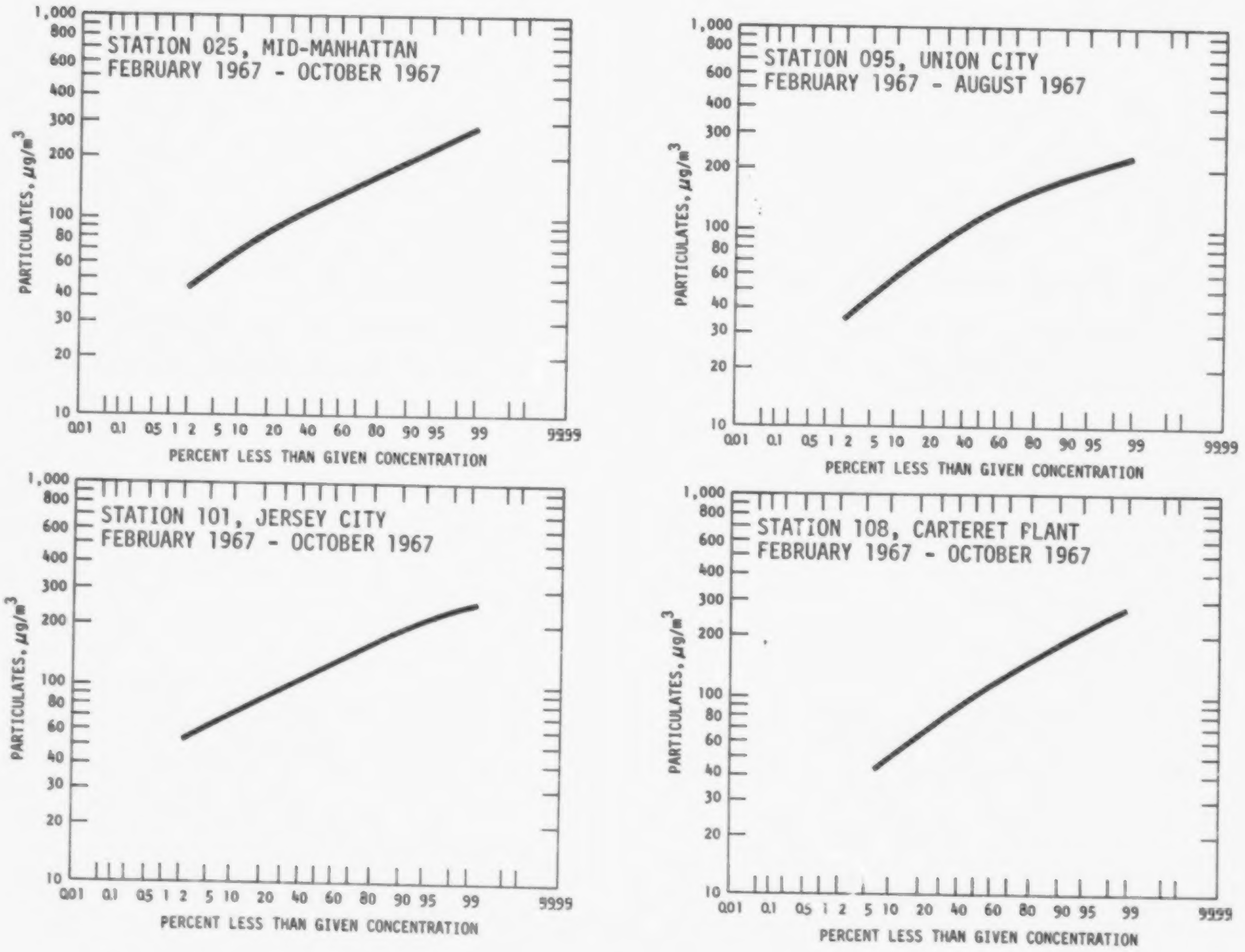

Figure D-13. Frequency distributions of suspended particulate - by high-volume samplers - at stations 025, 095, 101, and 108.

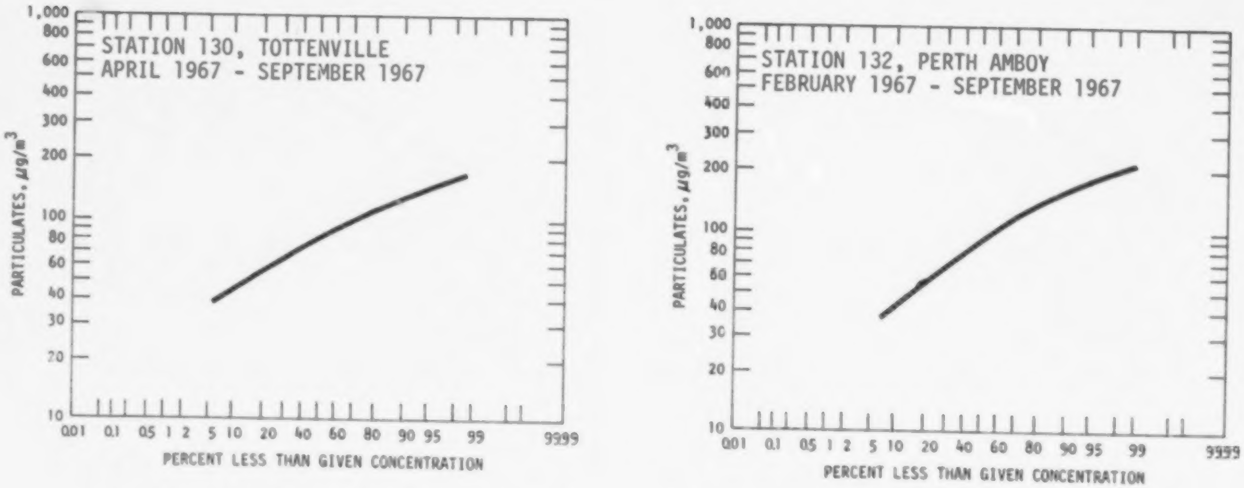

Figure D-14. Frequency distributions of suspended particulate - by high-volume samplers - at stations 130 and 132.

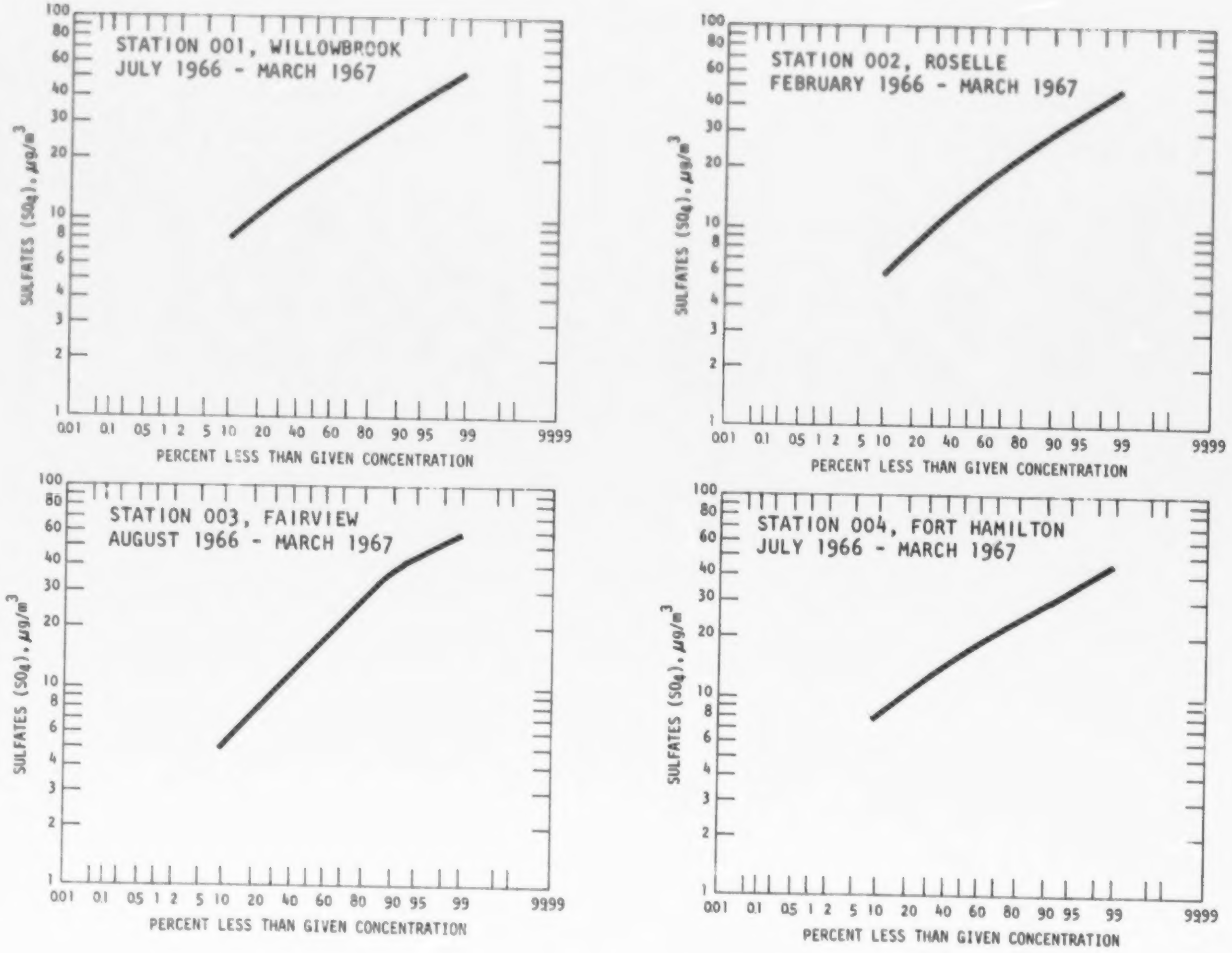

Figure D-15. Frequency distributions of sulfate at stations 001, 002, 003, and 004.

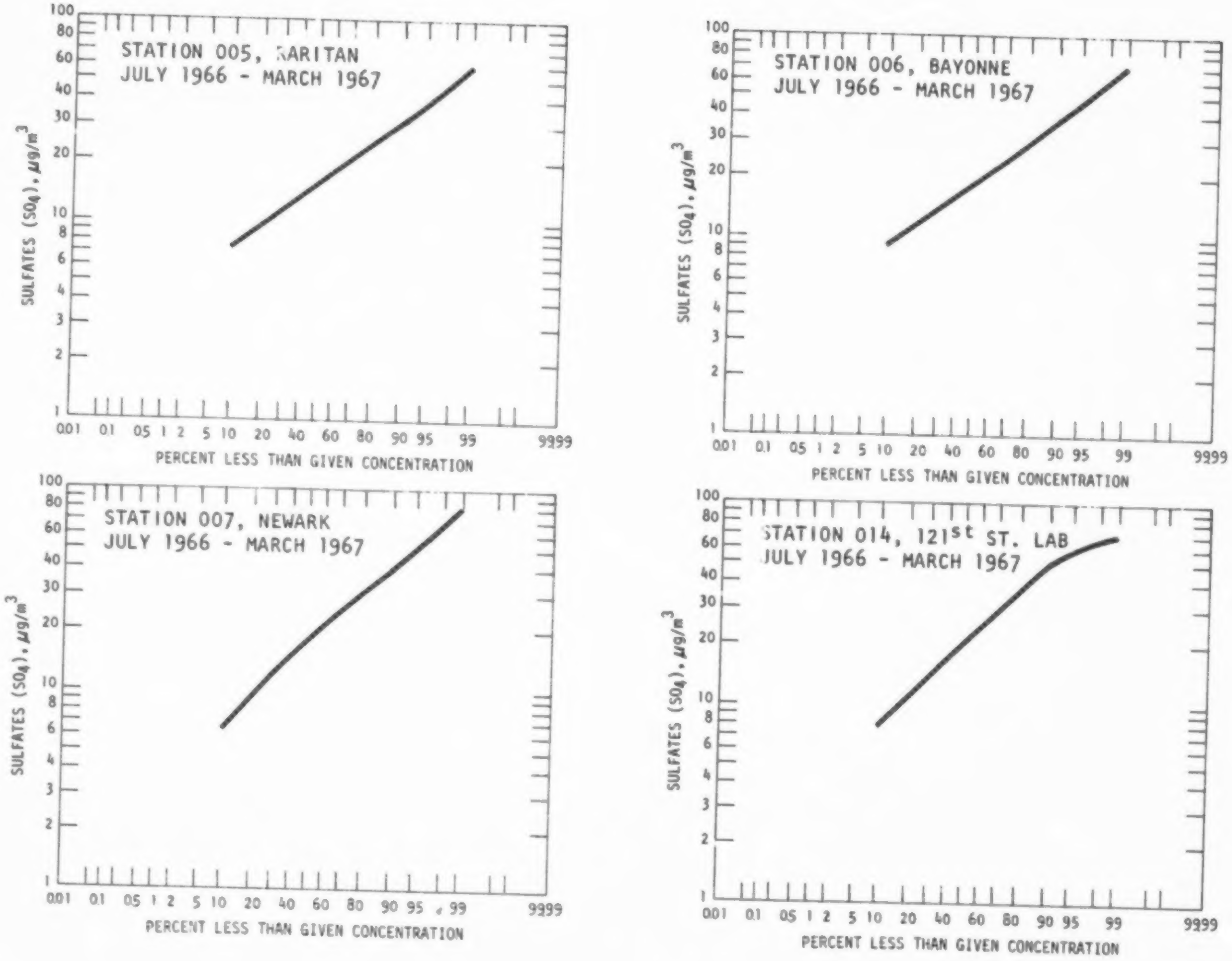

Figure D-16. Frequency distributions of sulfate at stations 005, 006, 007, and 014.

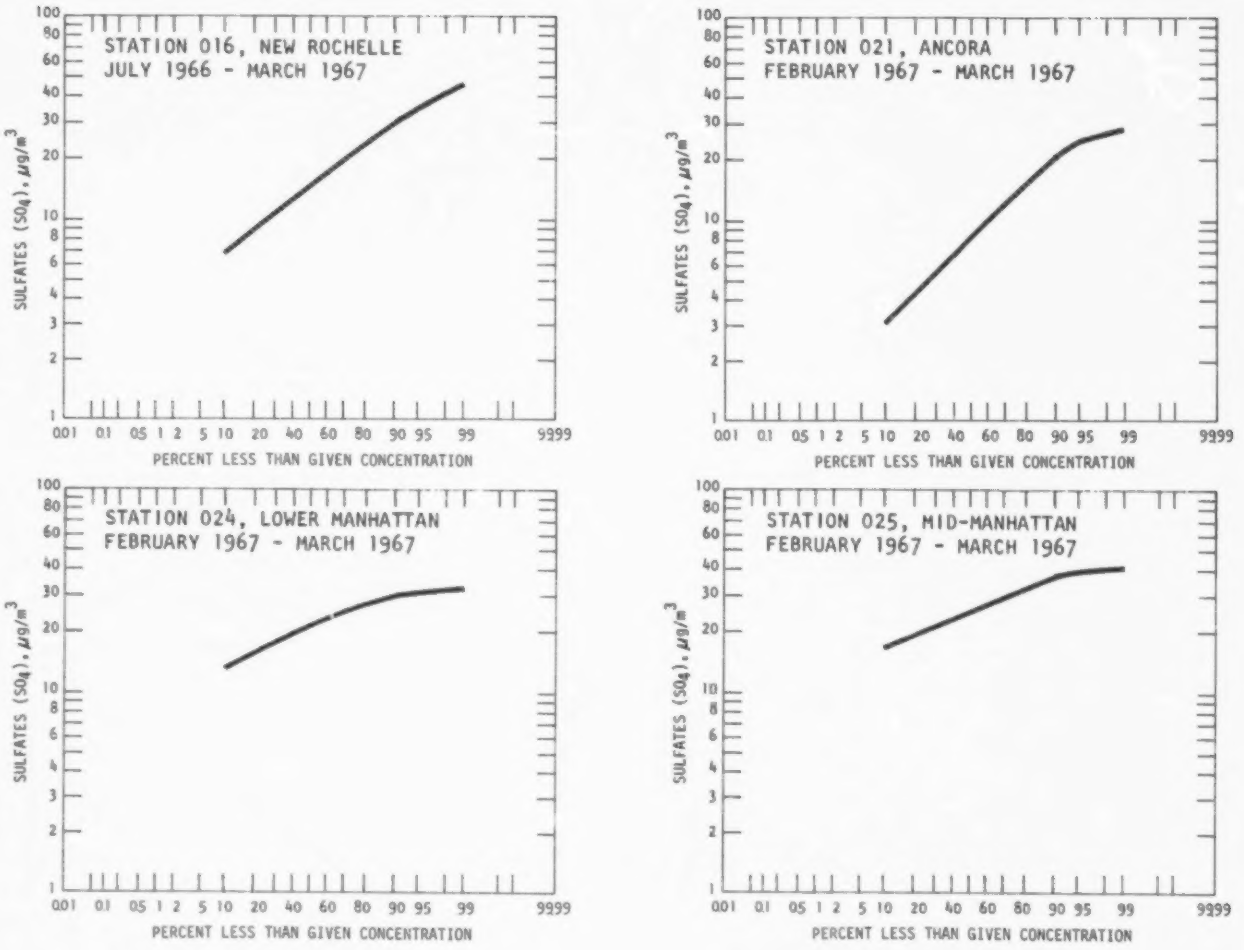

Figure D-17. Frequency distributions of sulfate at stations 016, 021, 024, and 025.

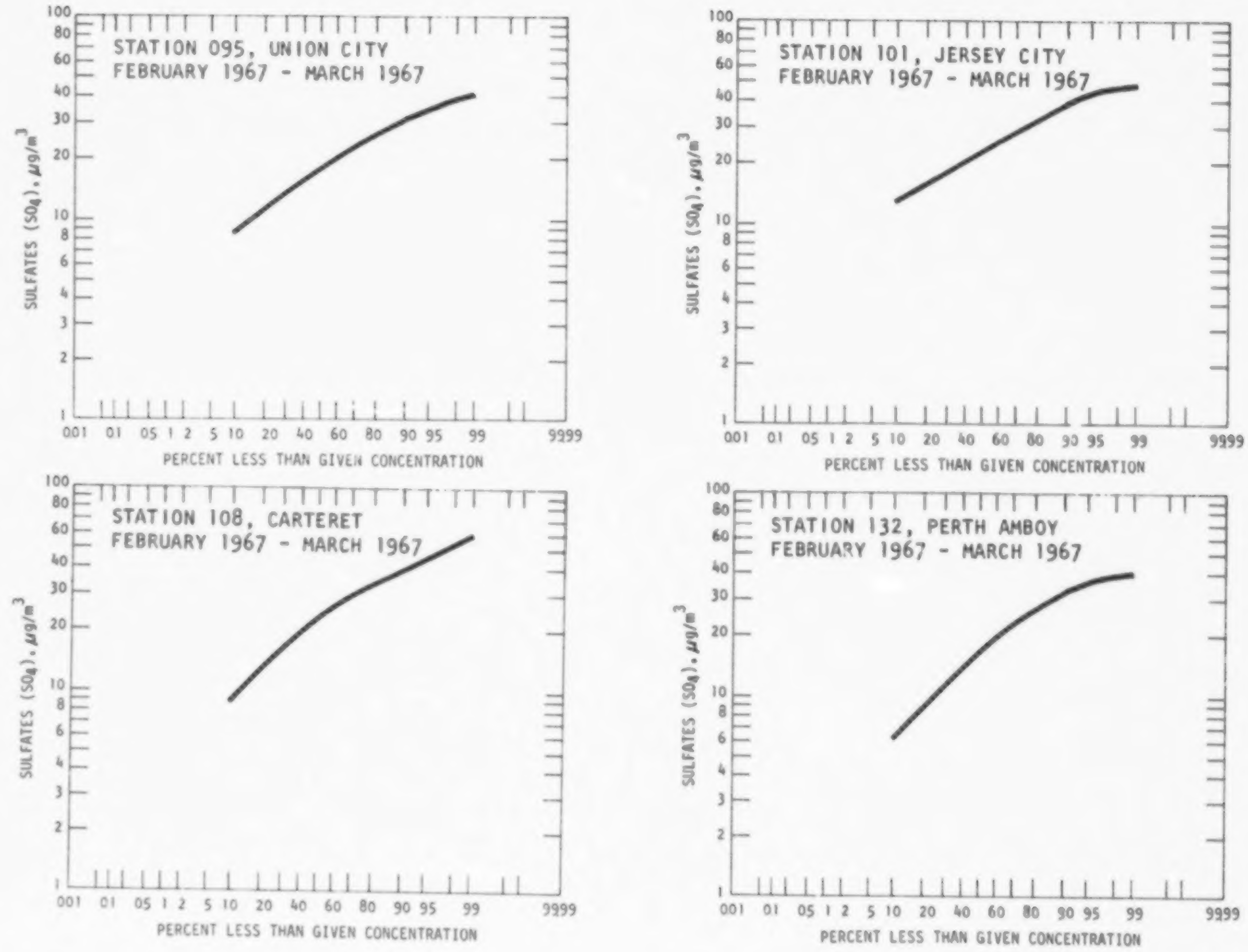

Figure D-18. Frequency distributions of sulfate at stations 095, 101, 108, and 132.

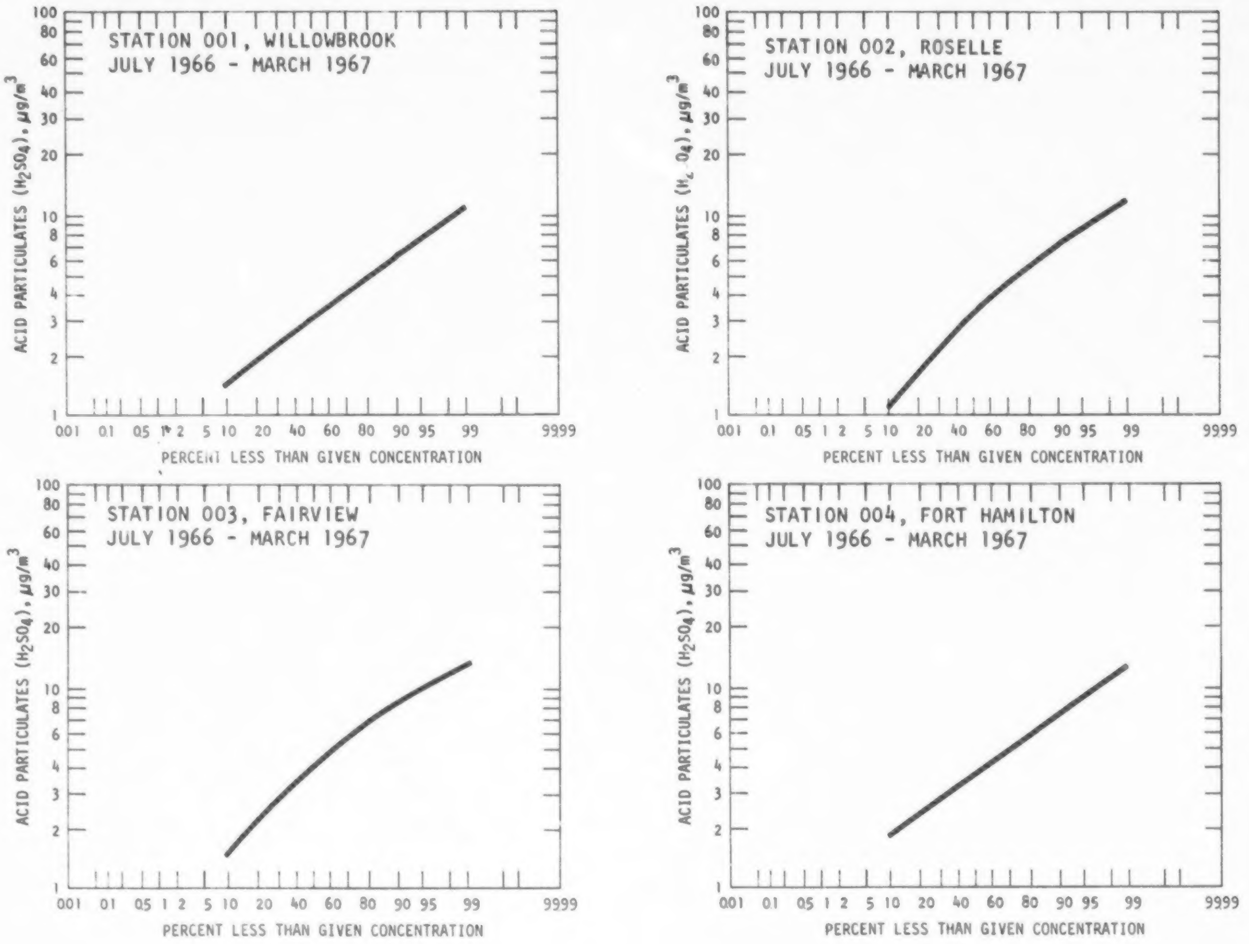

Figure D-19. Frequency distributions of acid particulates at stations 001, 002, 003, and 004.

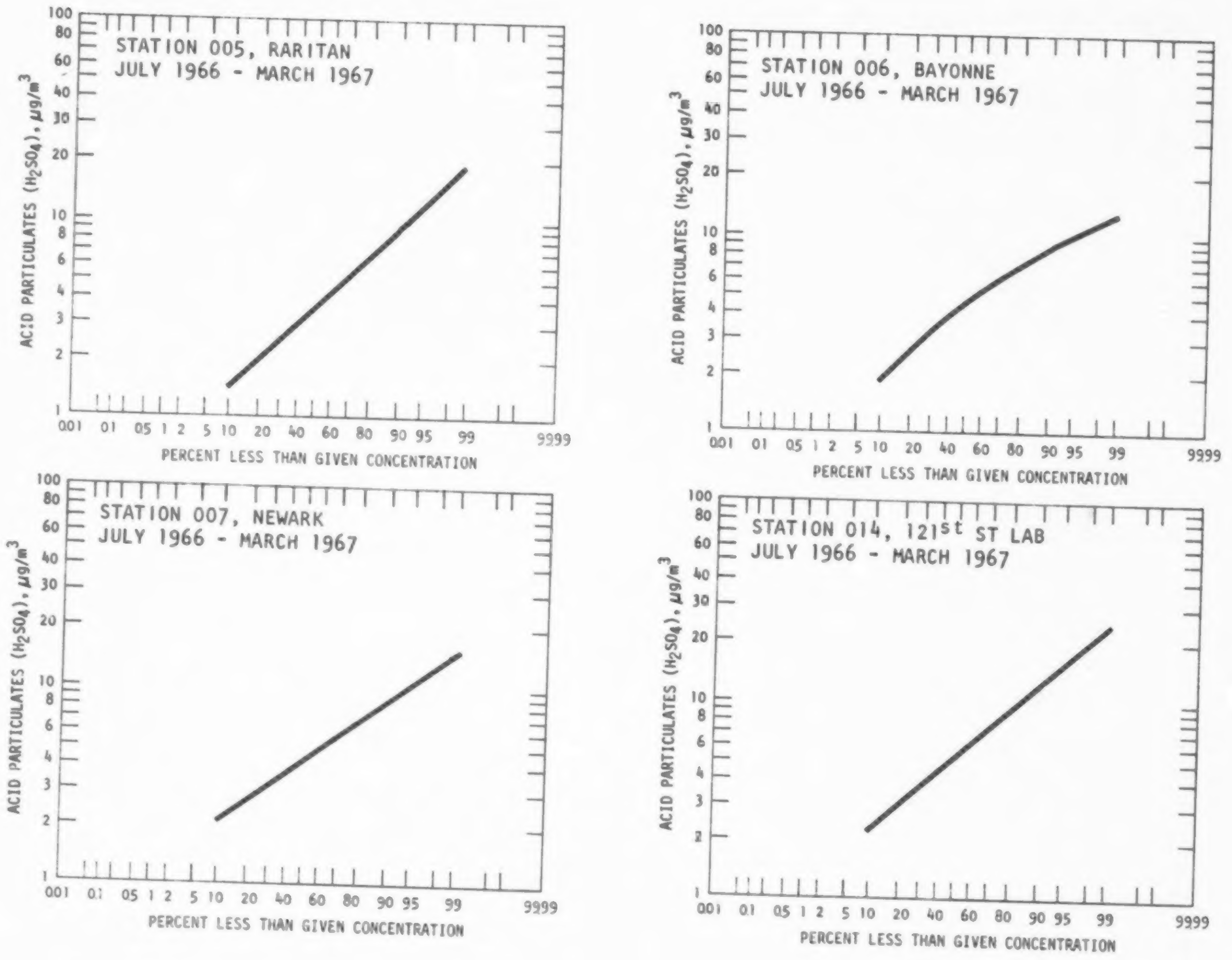

Figure D-20. Frequency distributions of acid particulates at stations 005, 006, 007, and 014.

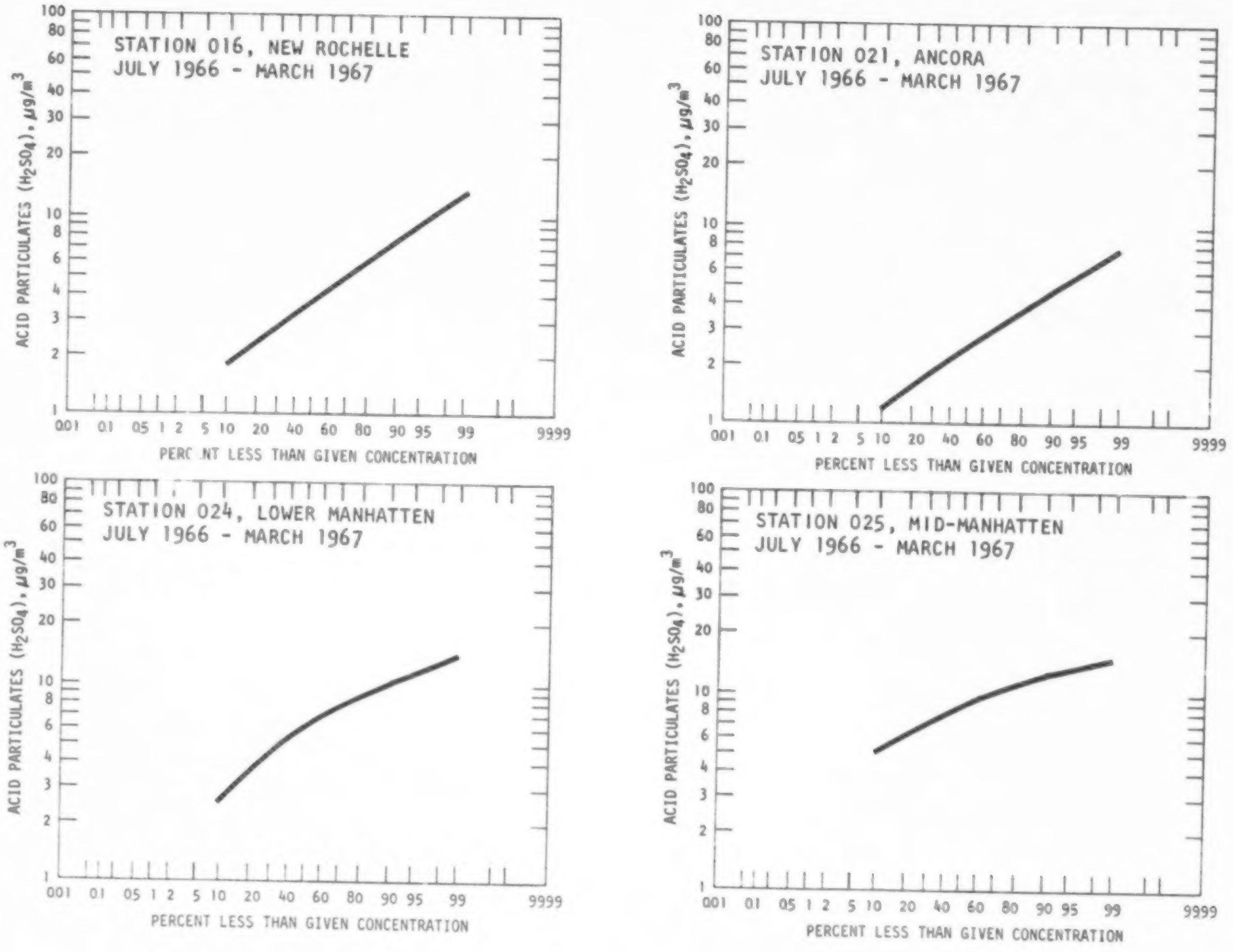

Figure D-21. Frequency distributions of acid particulates at stations 016, 021, 024, and 025.

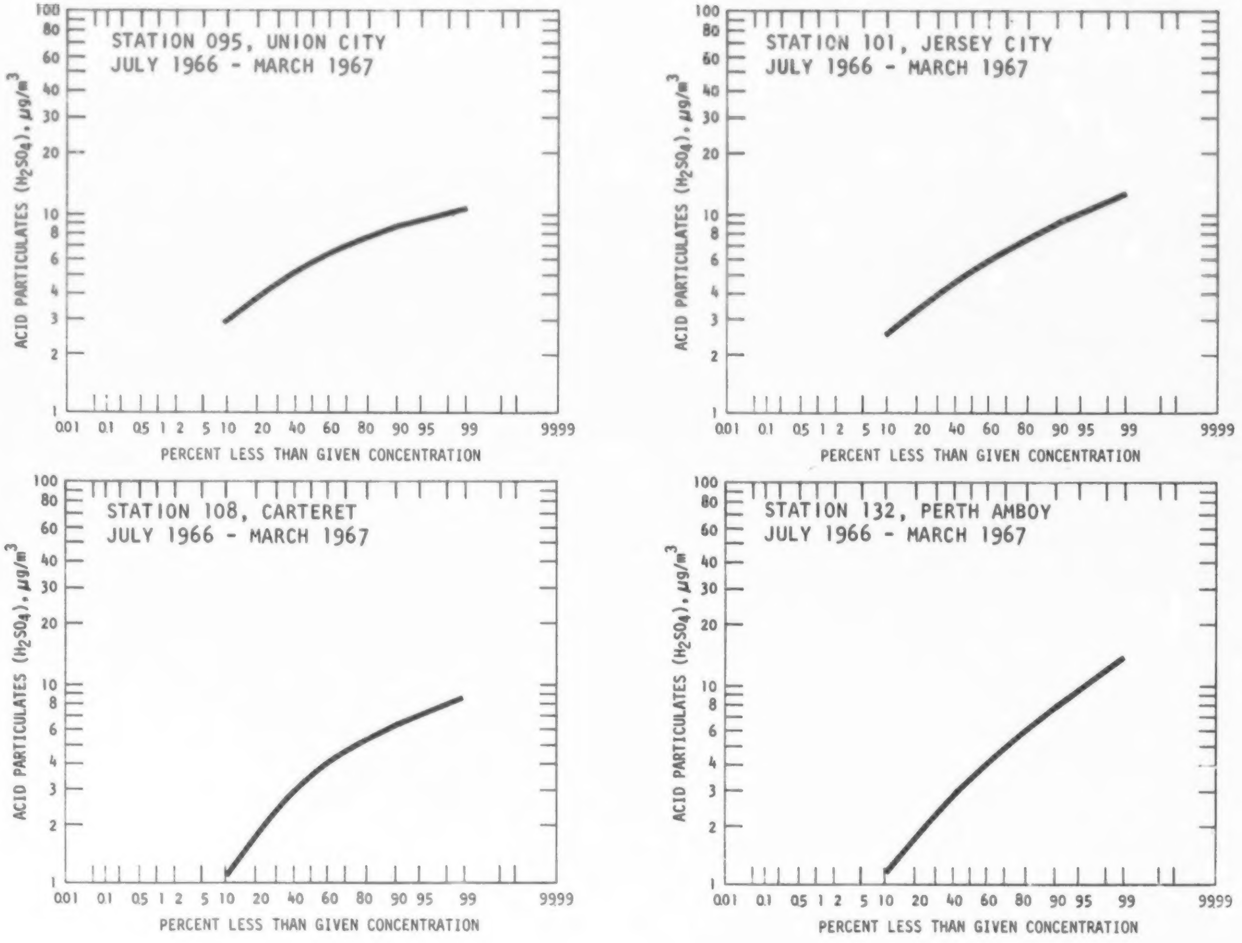

Figure D-22. Frequency distributions of acid particulates at stations 095, 101, 108, and 132.

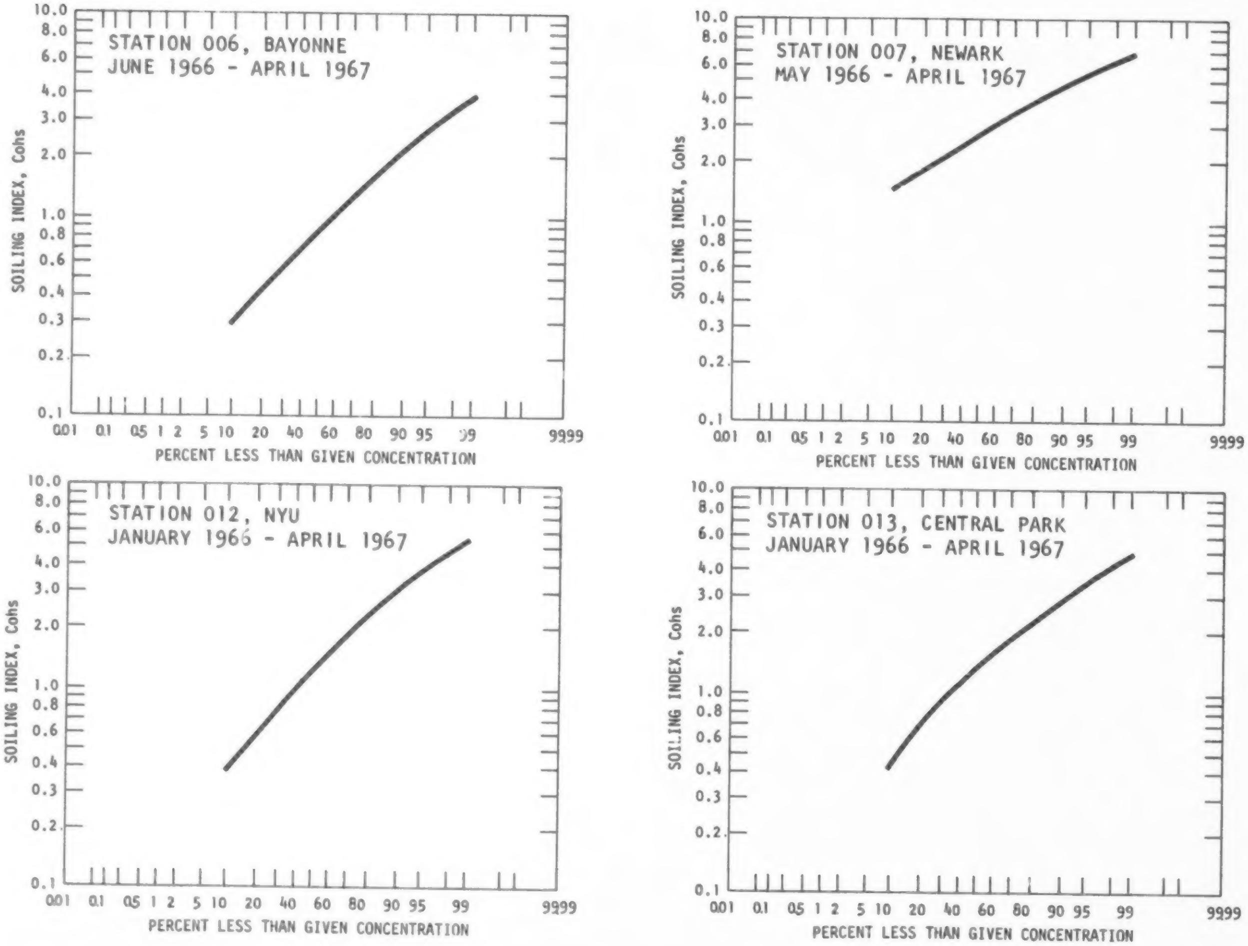

Figure D-23. Frequency distributions of suspended particulate - by AISI samplers - at stations 006, 007, 012, and 013.

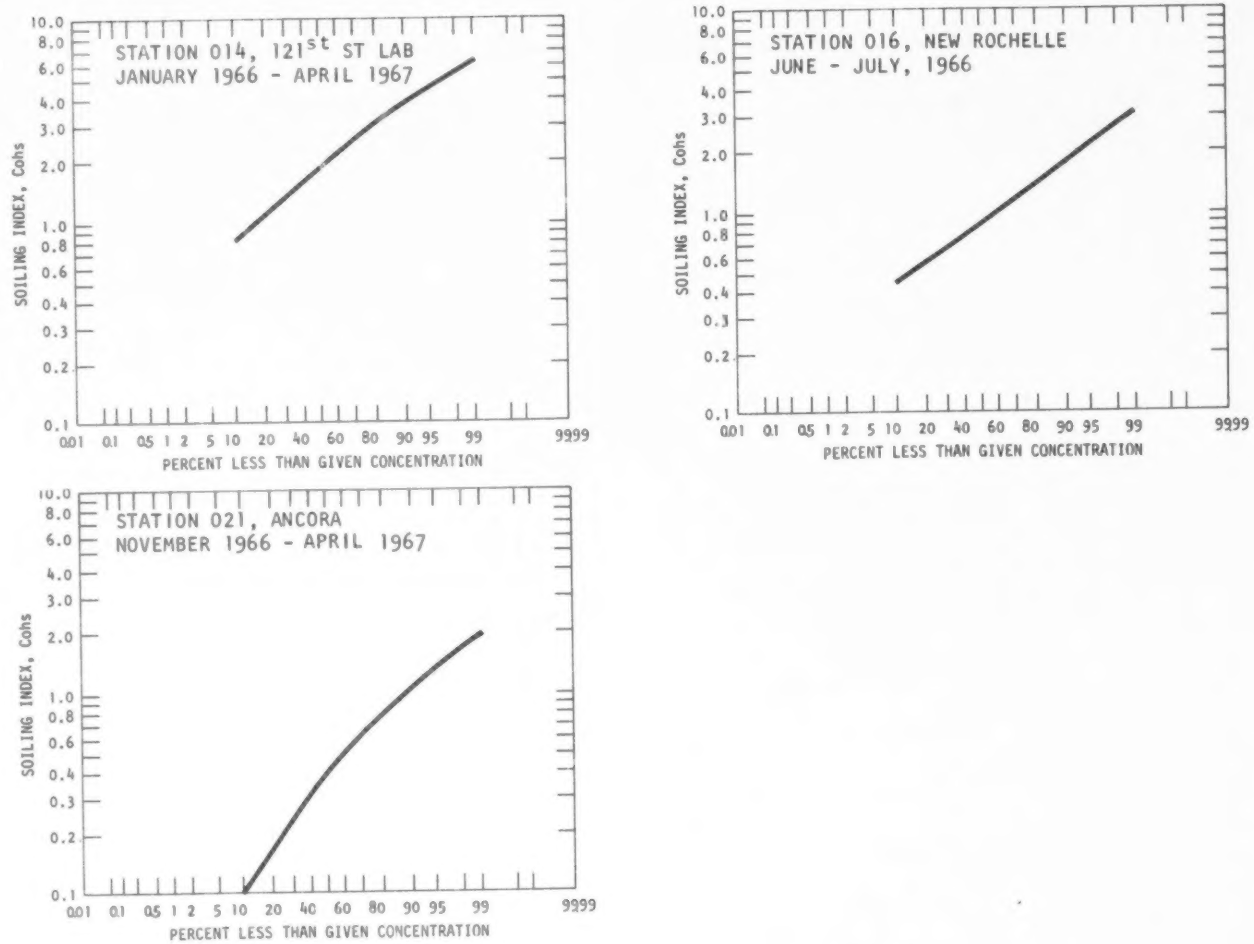

Figure D-24. Frequency distributions of suspended particulate - by AISI samplers - at stations 014, 016, and 021.

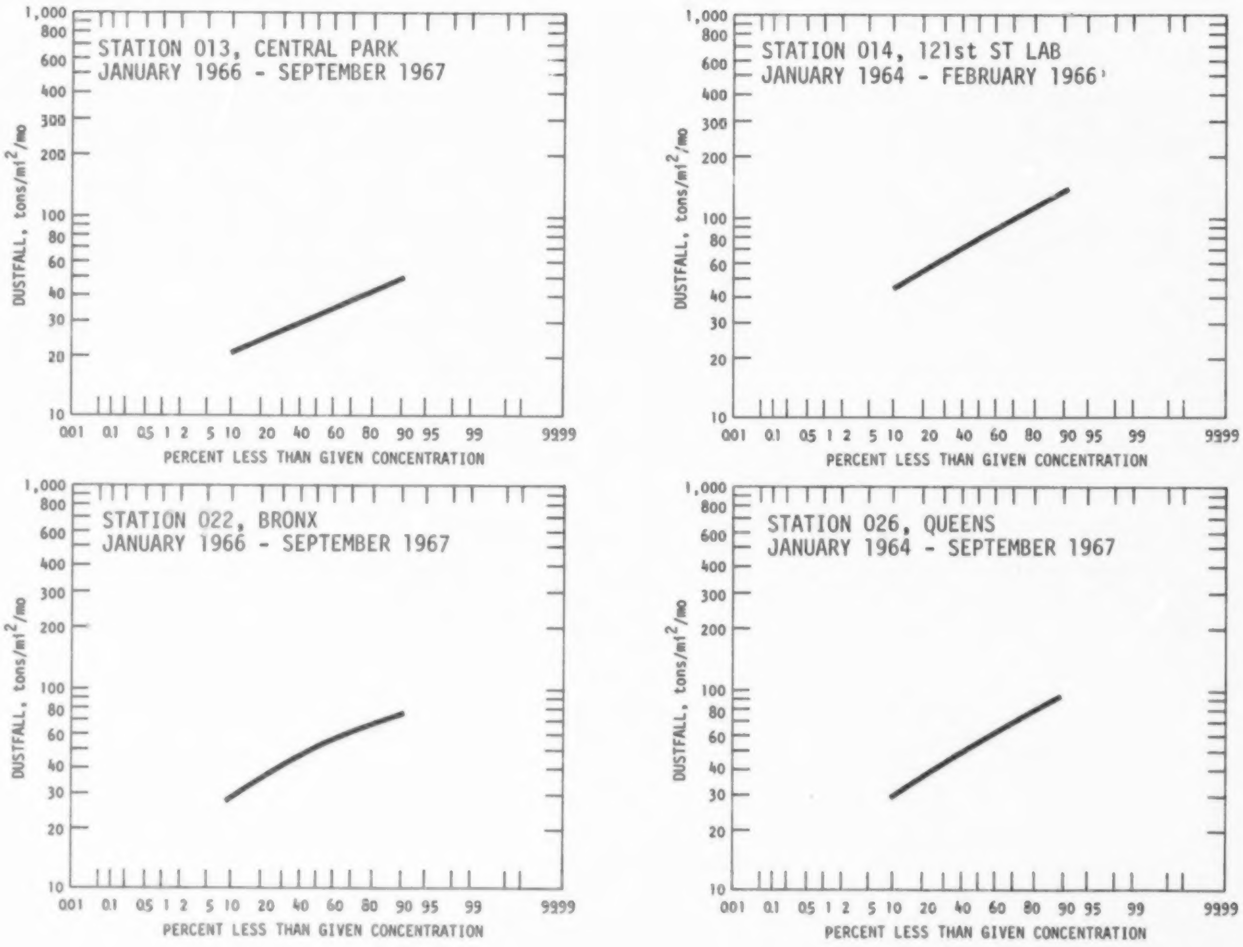

Figure D-25. Frequency distributions of dustfall at stations 013, 014, 022, and 026.

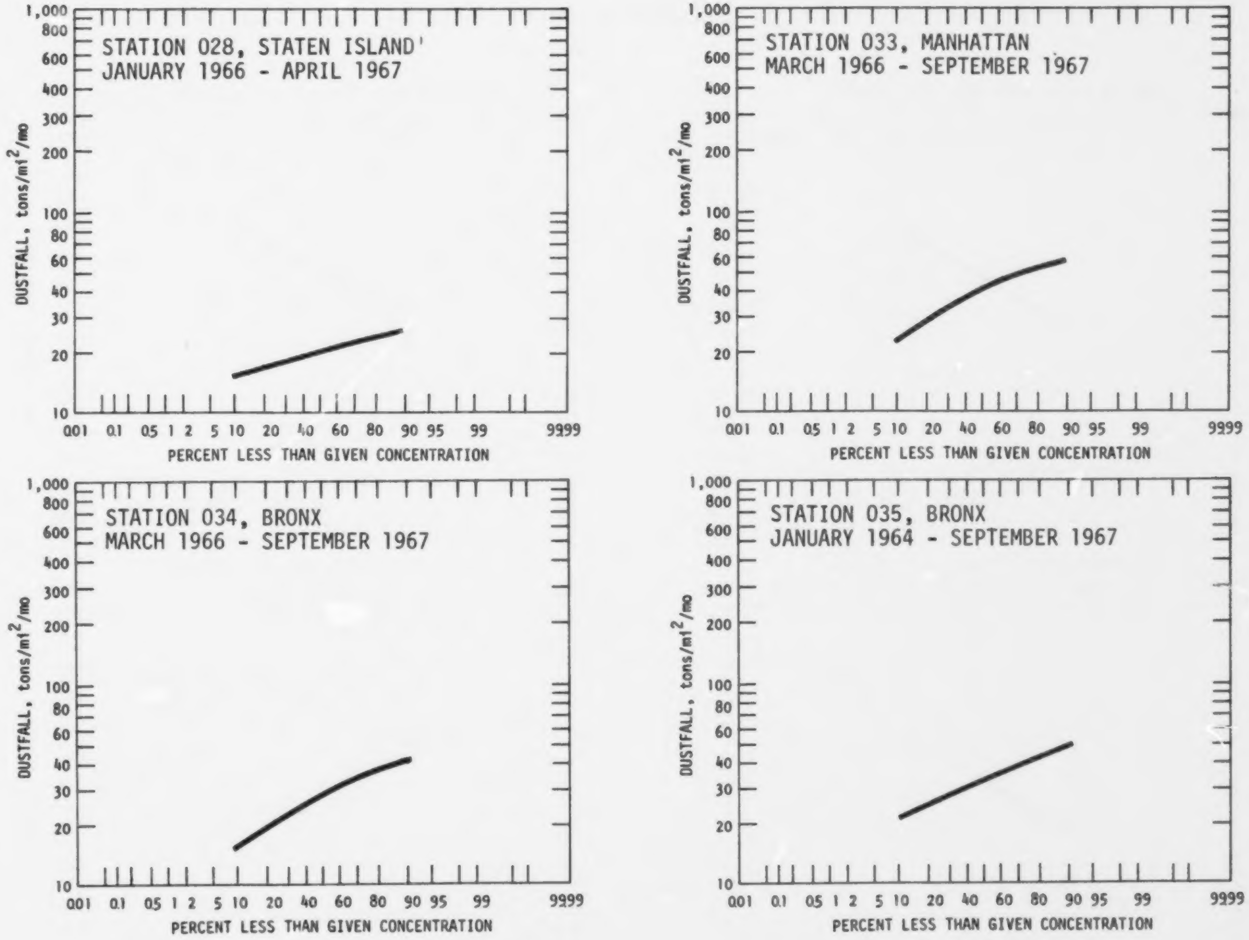

Figure D-26. Frequency distributions of dustfall at stations 028, 033, 034, and 035.

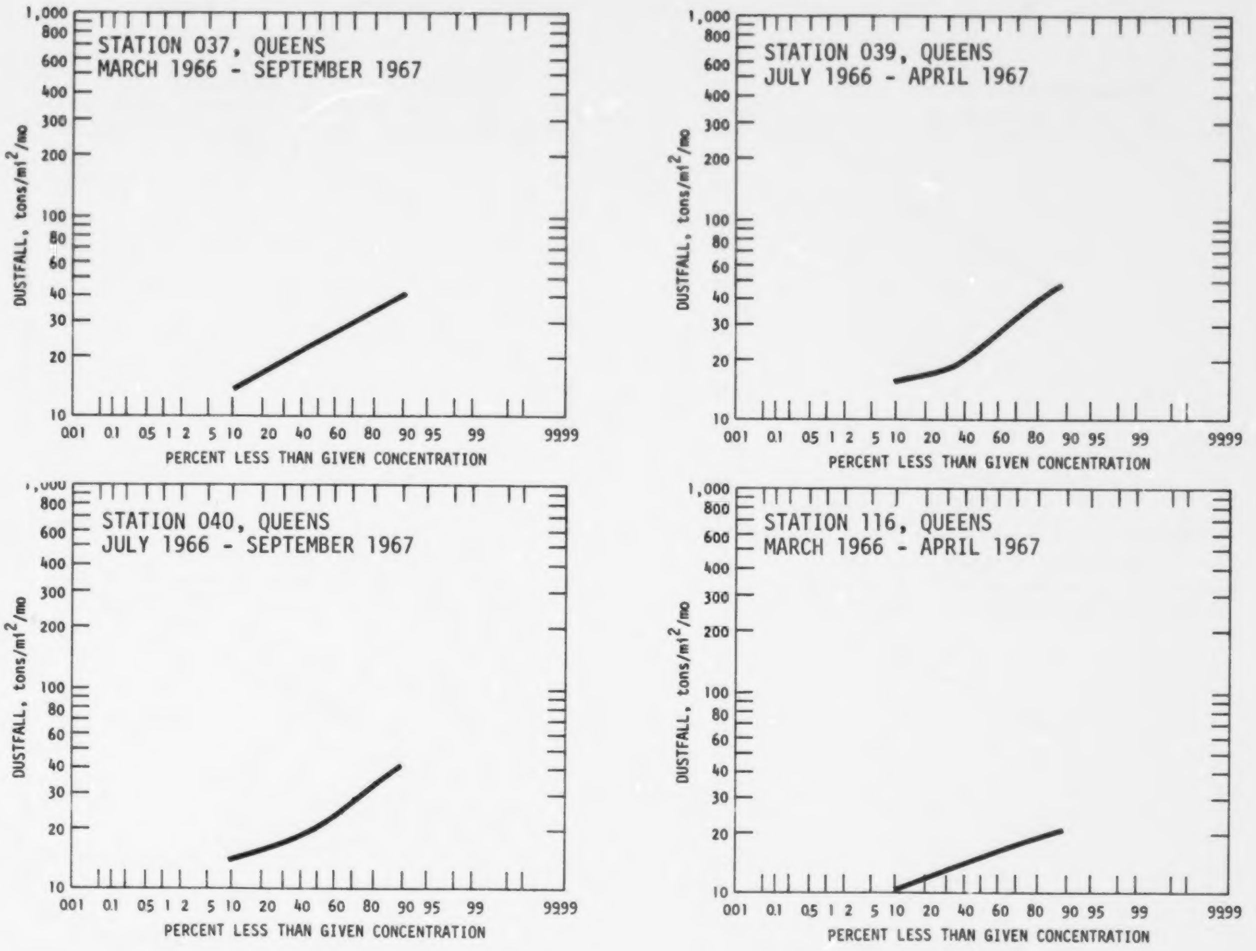

Figure D-27. Frequency distributions of dustfall at stations 037, 039, 040, and 116.

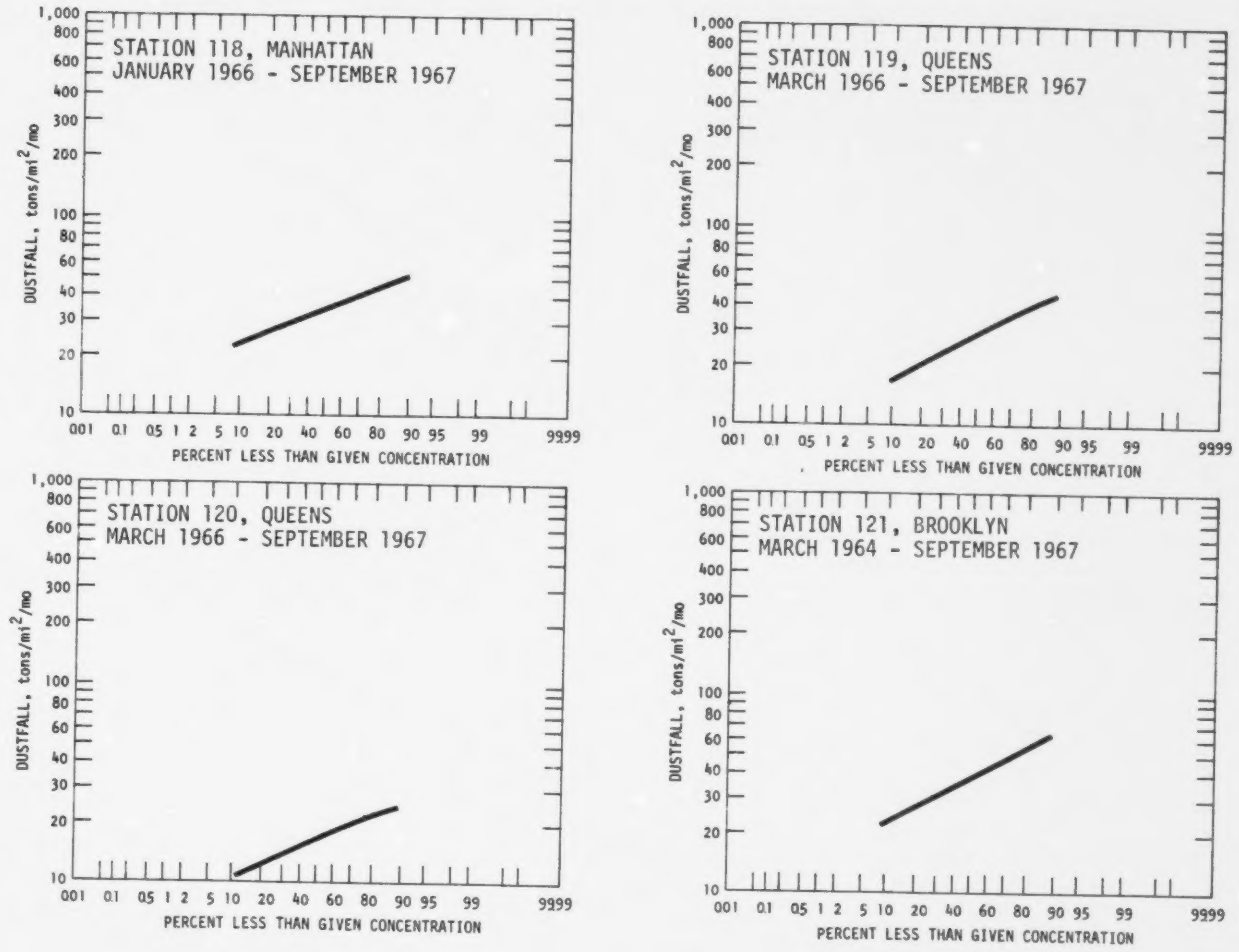

Figure D-28. Frequency distributions of dustfall at stations 118, 119, 120, and 121.

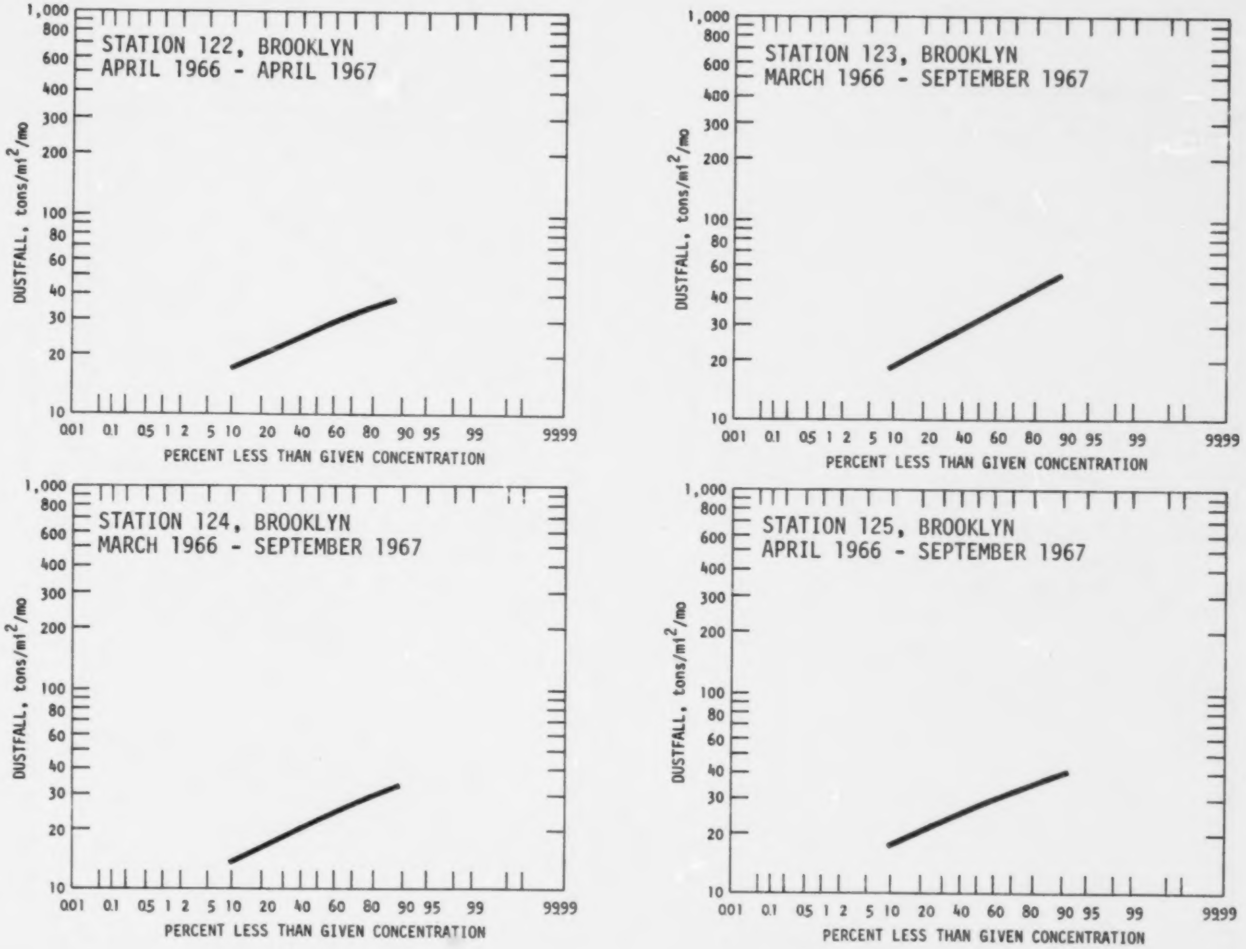

Figure D-29. Frequency distributions of dustfall at stations 122, 123, 124, and 125.

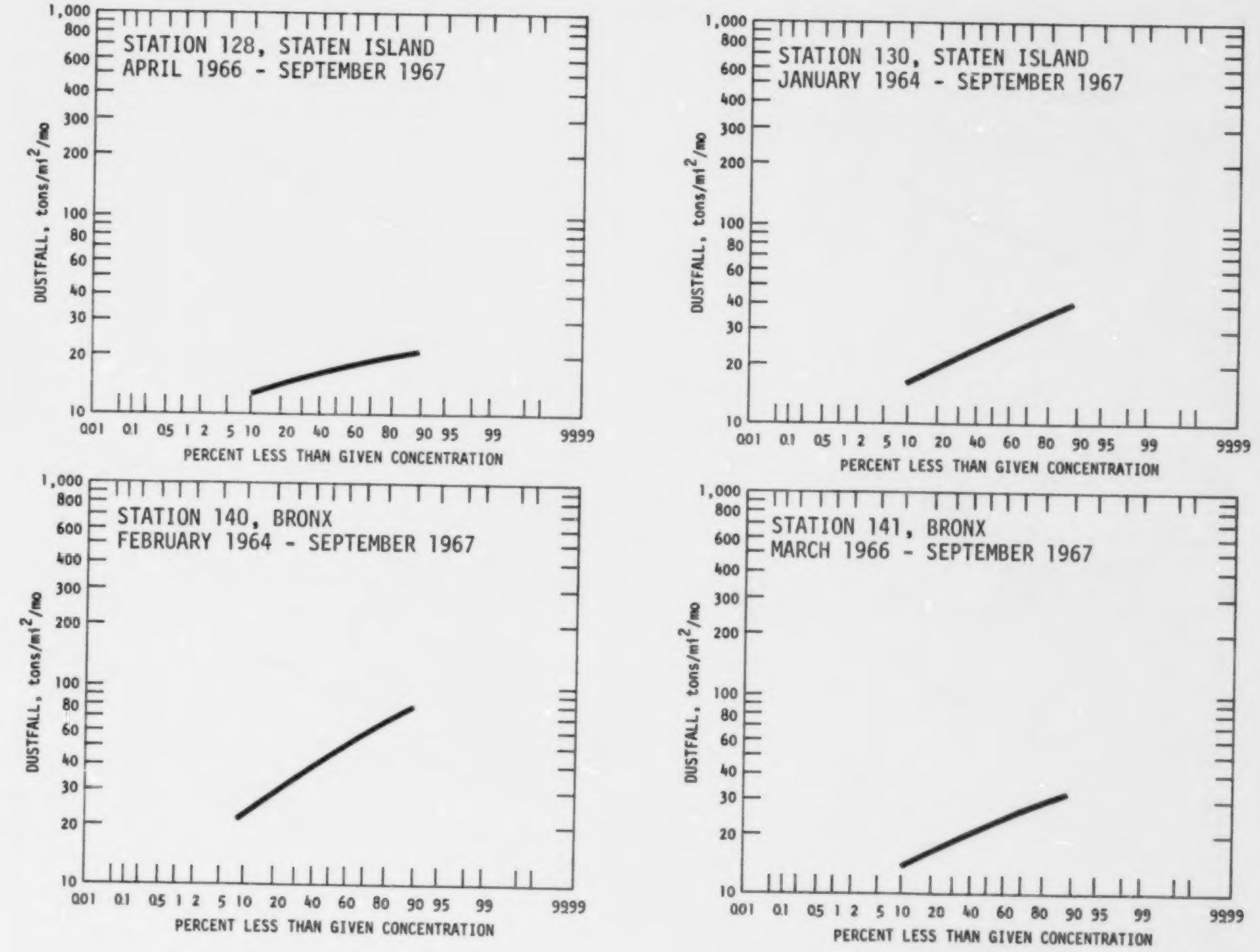

Figure D-30. Frequency distributions of dustfall at stations 128, 130, 140, and 141.

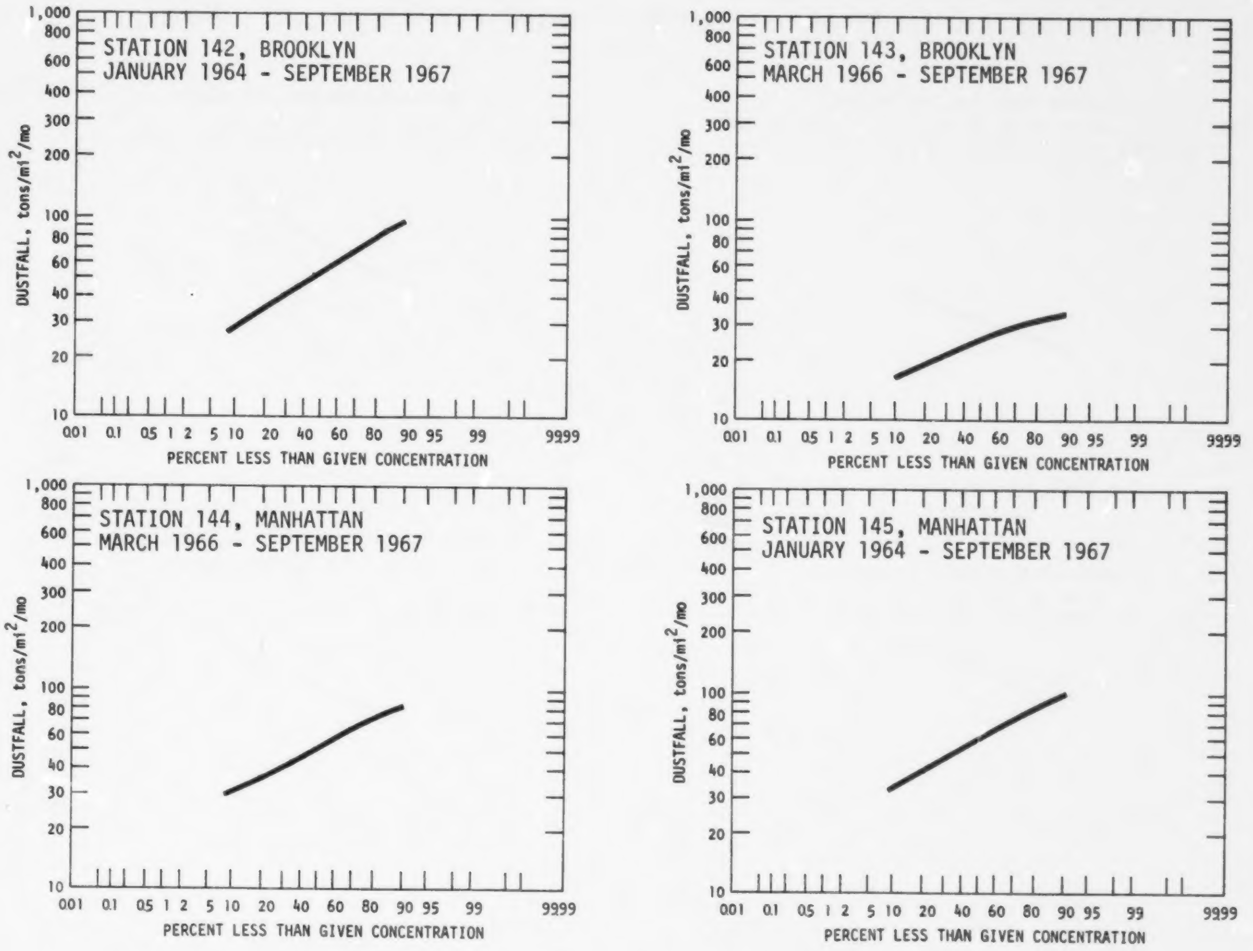

Figure D-31. Frequency distributions of dustfall at stations 142, 143, 144, and 145.

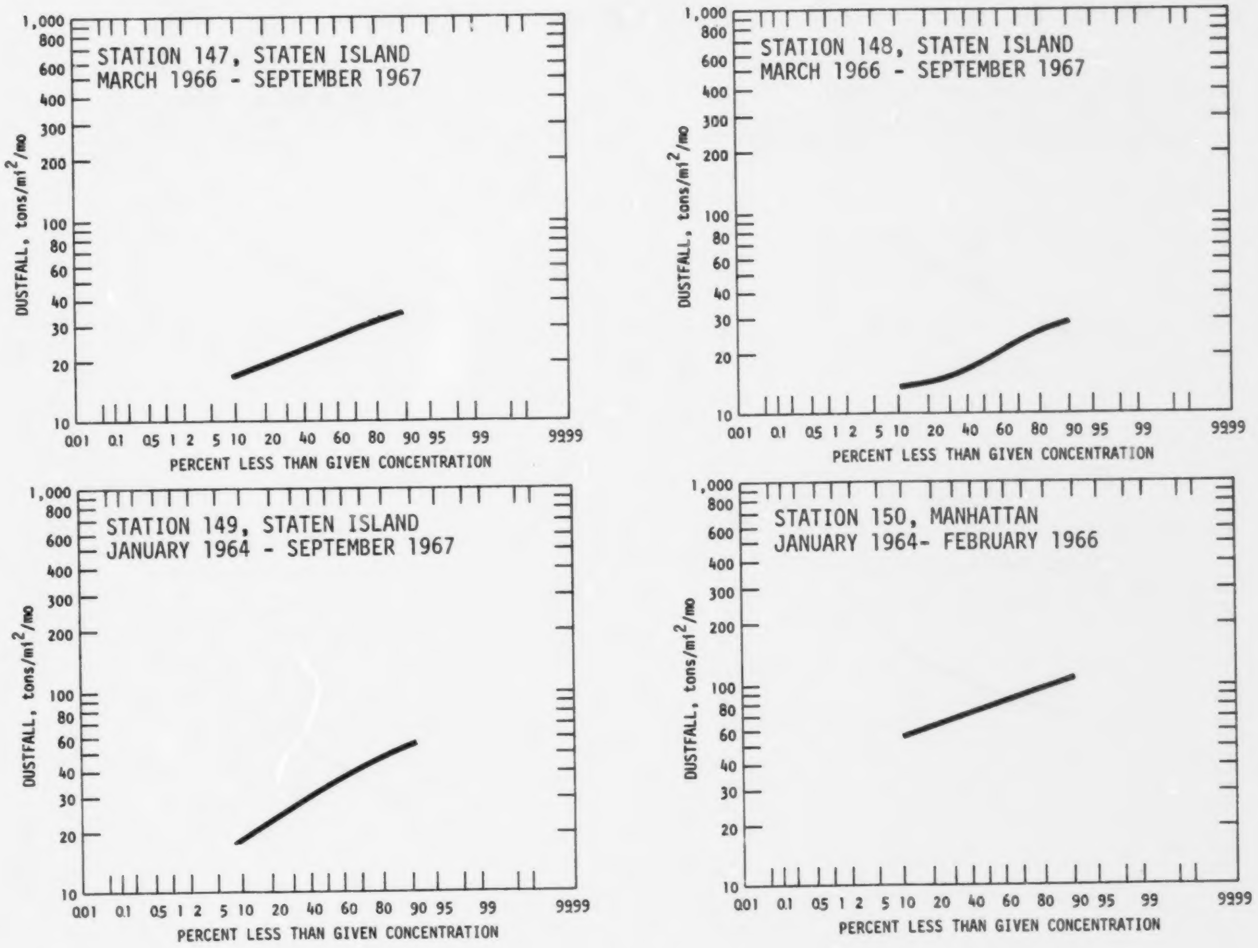

Figure D-32. Frequency distributions of dustfall at stations 147, 148, 149, and 150.

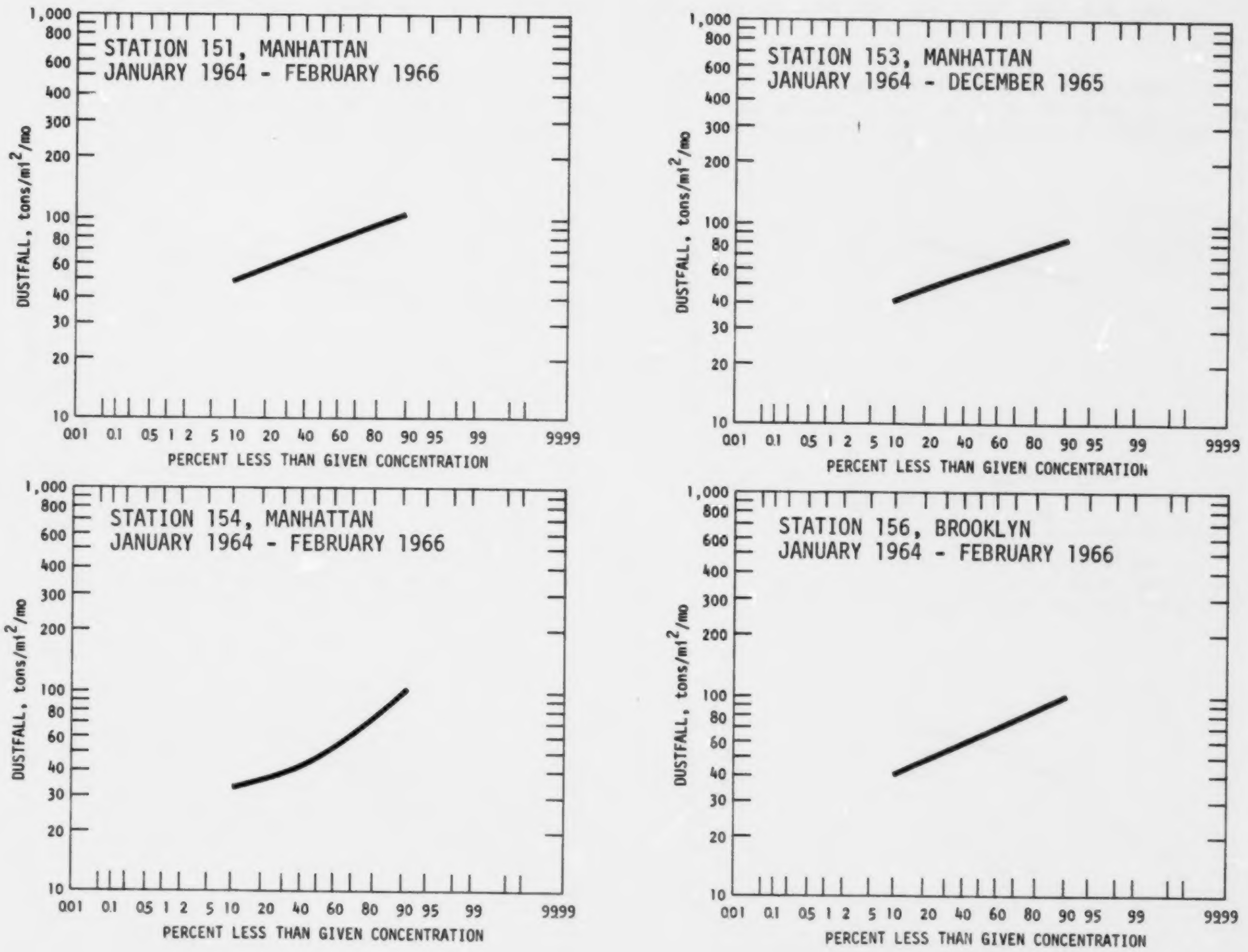

Figure D-33. Frequency distributions of dustfall at stations 151, 153, 154, and 156.

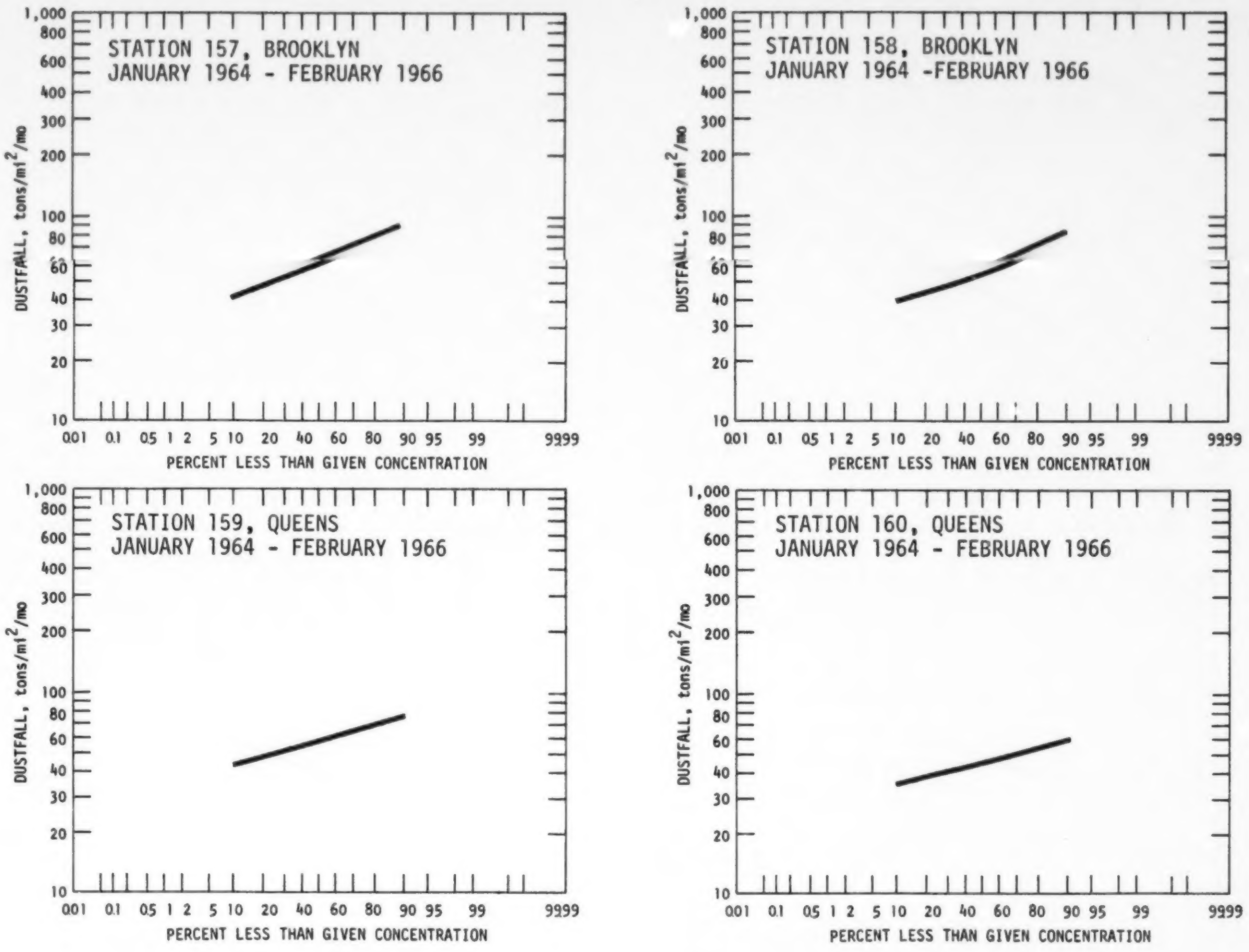

Figure D-34. Frequency distributions of dustfall at stations 157, 158, 159, and 160.

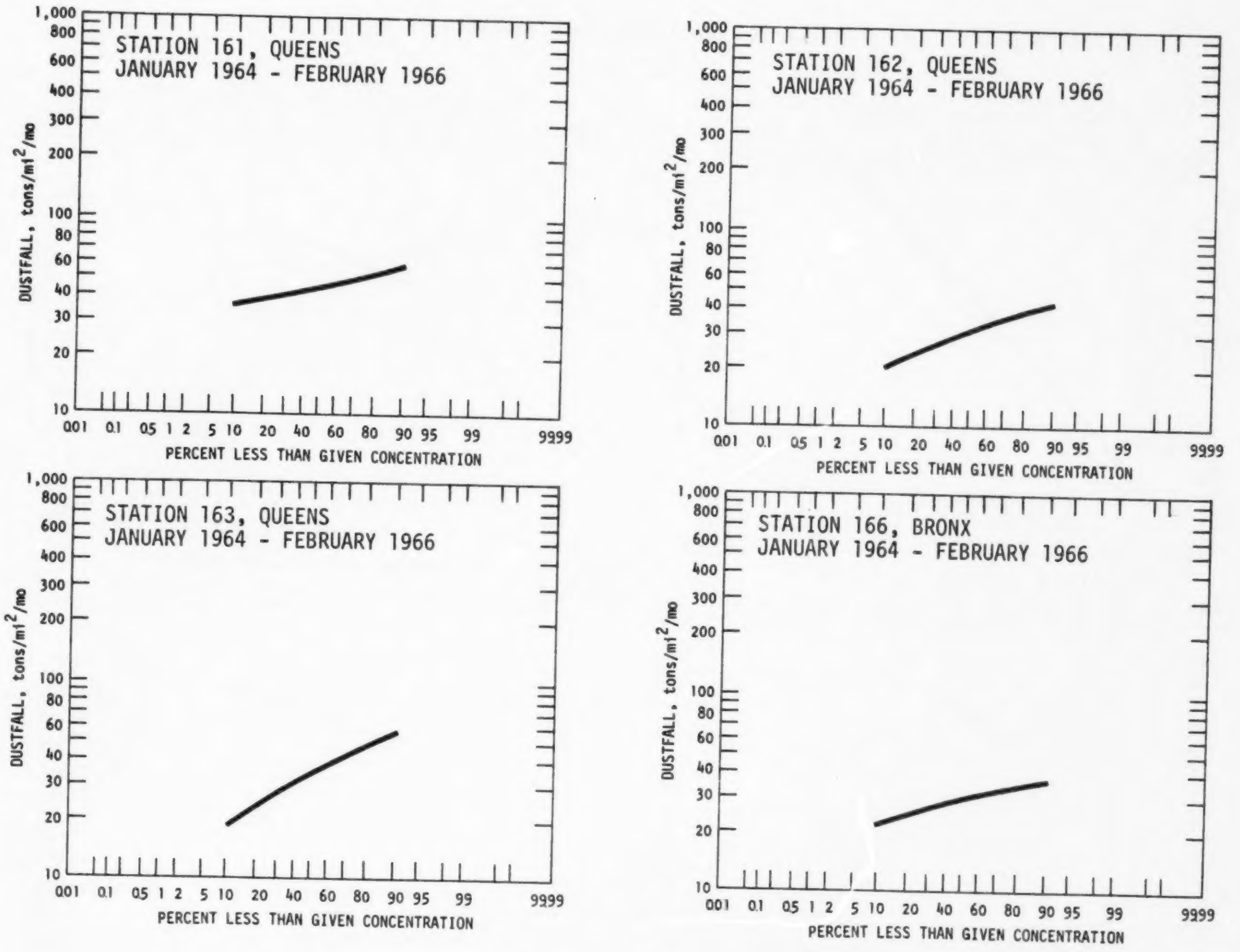

Figure D-35. Frequency distributions of dustfall at stations 161, 162, 163, and 166.

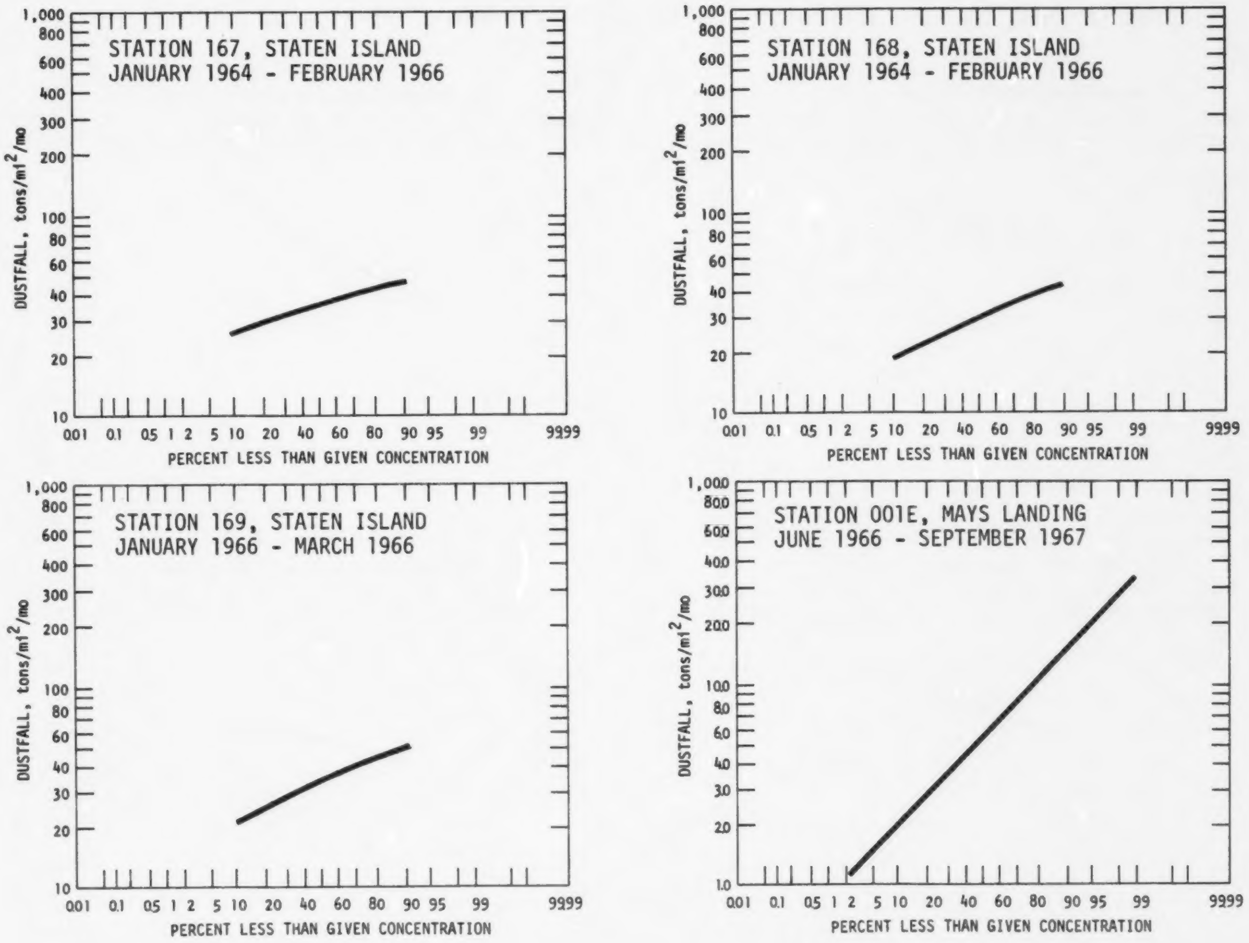

Figure D-36. Frequency distributions of dustfall at stations 167, 168, 169, and 001E.

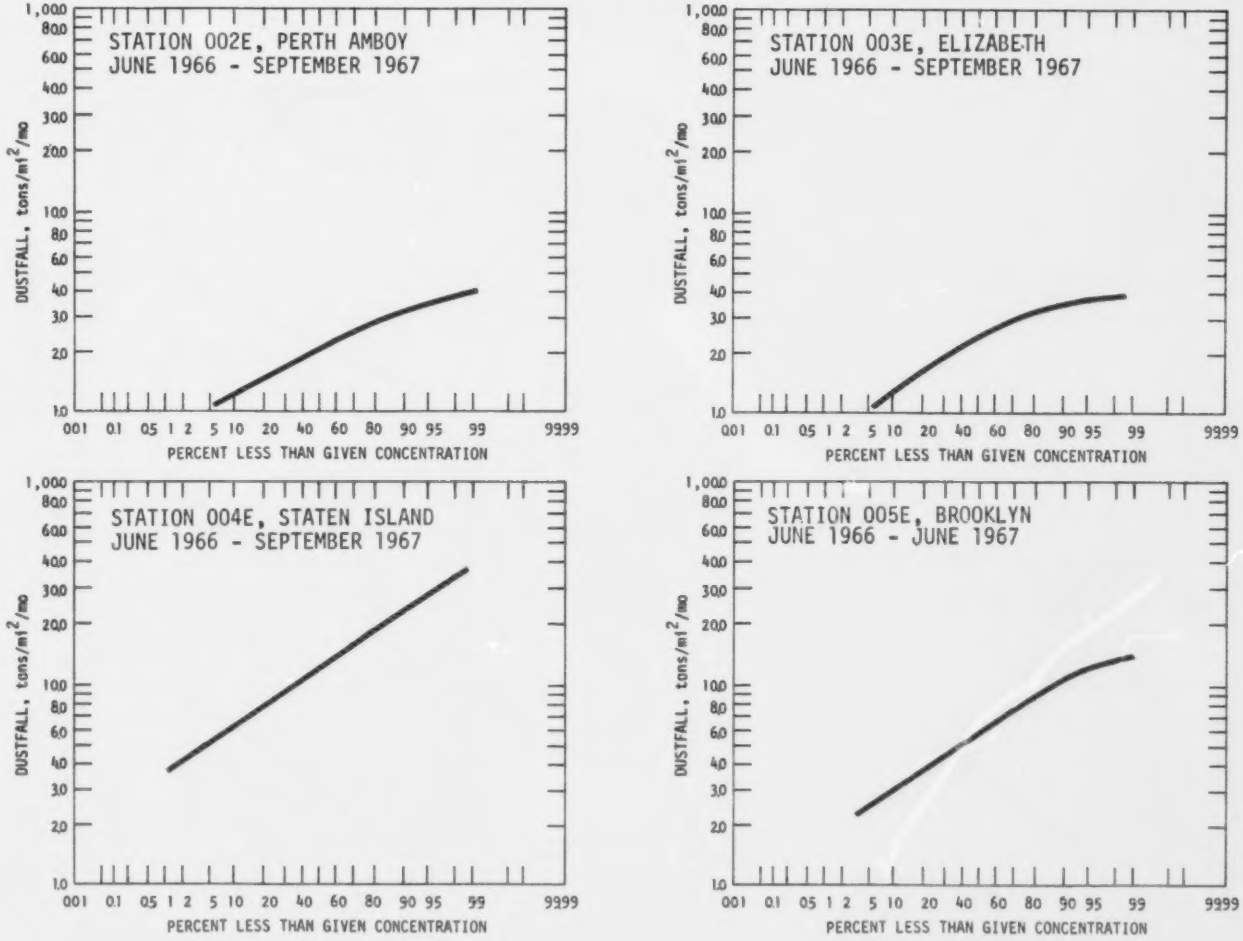

Figure D-37. Frequency distributions of dustfall at stations 002E, 003E, 004E, and 005E.

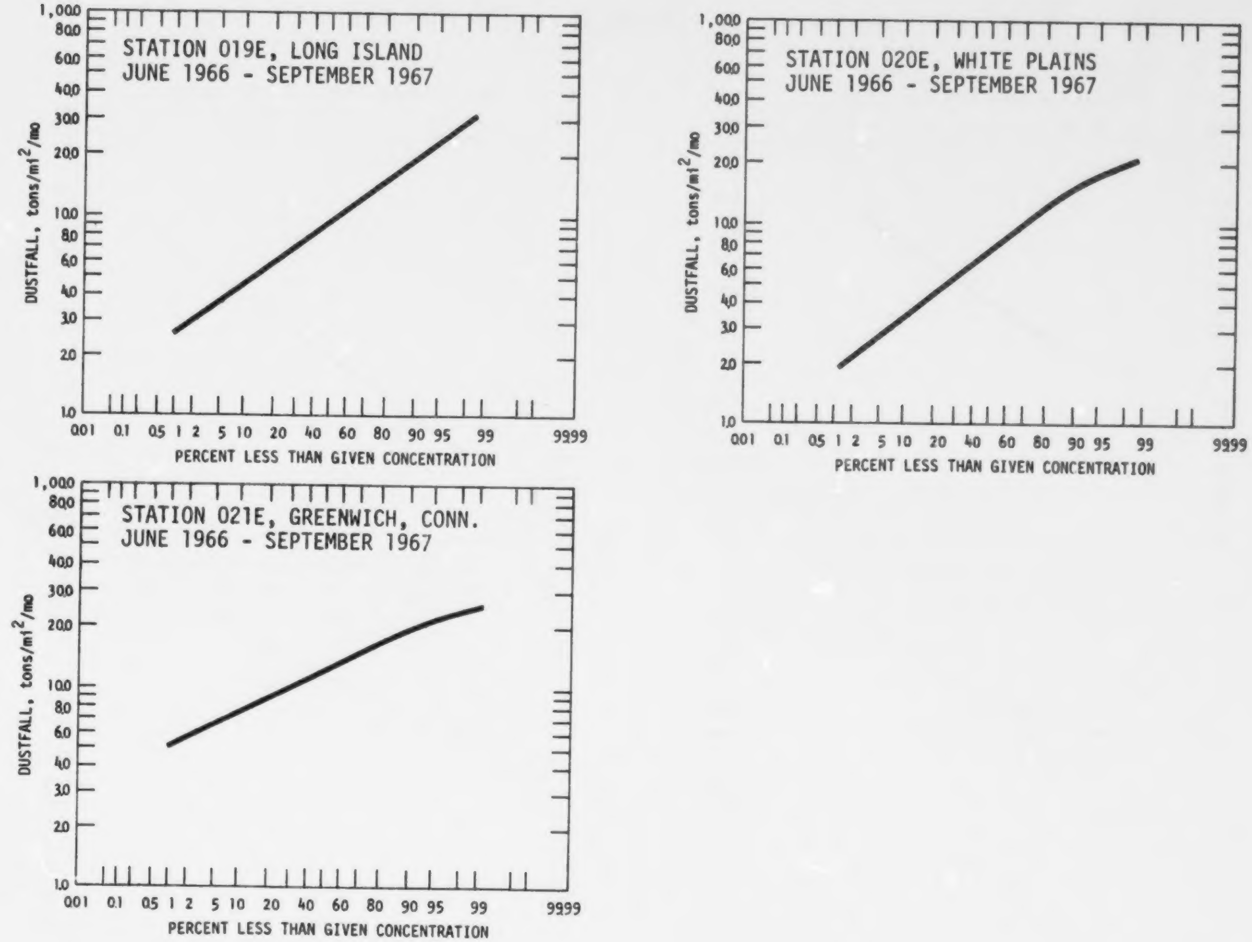

Figure D-38. Frequency distributions of dustfall at stations 019E, 020E, and 021E.